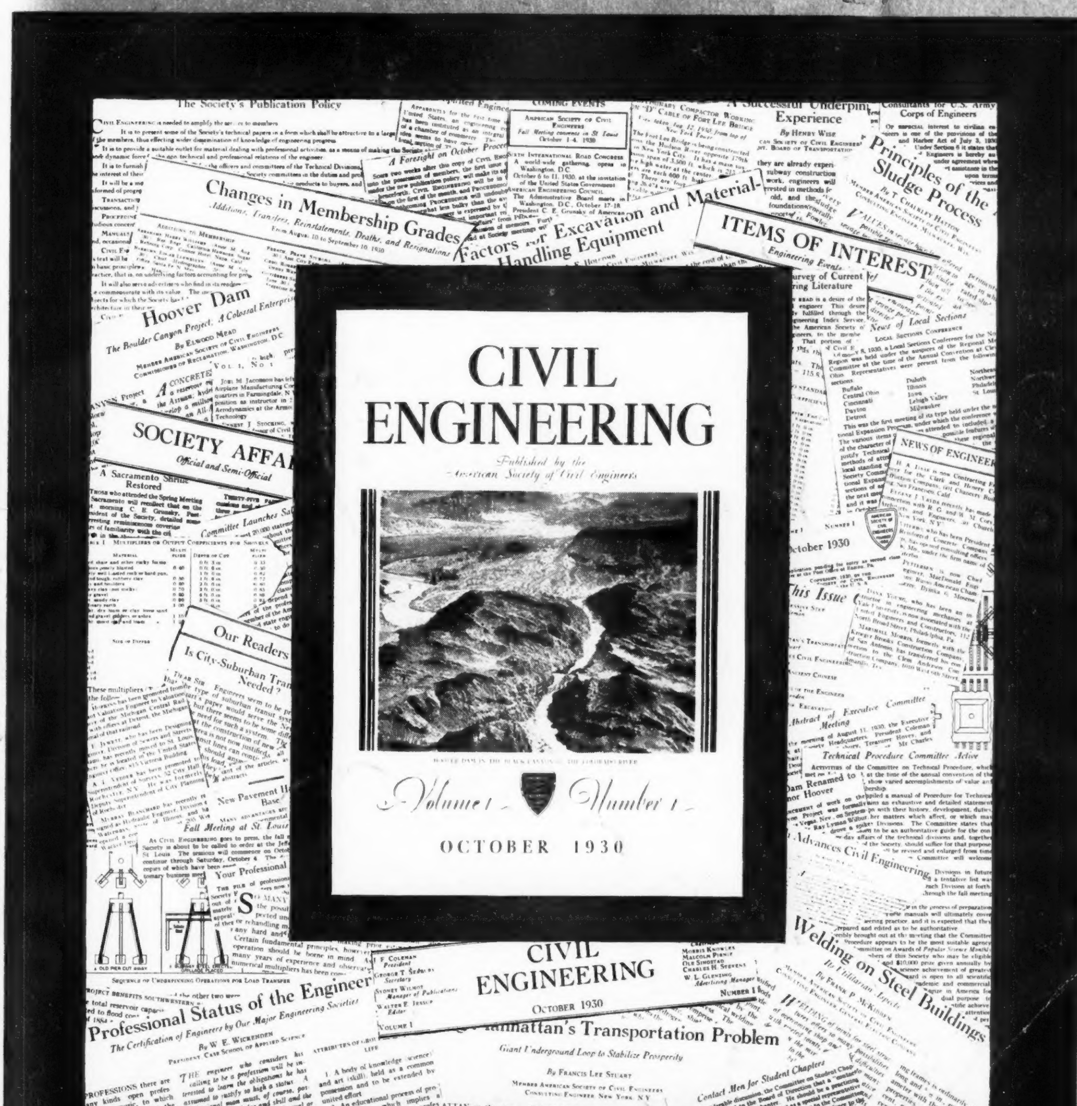
CIVIL ENGINEERING

OCTOBER 1955

THE MAGAZINE OF ENGINEERED CONSTRUCTION



25TH ANNIVERSARY ISSUE

Mechanical Loading Speeds Construction

Tractor-Excavators in African copper mines are helping to speed road building projects. The picture above shows an Eimco 105 loading trucks at the rate of 300-350 yards per hour (at left note view of old method which is continuation of featured picture on right hand side).

Speeding highways, construction jobs and earth or rock moving jobs of all kinds is done most economically with Eimco equipment.

The Eimco is revolutionary — it prompts a new concept in estimating the cost of jobs requiring material handling equipment.

In the lower picture at right, the Eimco is loading a piece of rock estimated to contain at least 35 cubic feet. Its shape would require that it be broken to be loaded with other types of equipment but the Eimco easily loads it overhead into the 21 yard rock wagon.

Loading large rock wagons of this type is done 90% efficiently from the end or 100% efficiently from the side. Some jobs in narrow cuts or highway widening jobs must use end loading and no other equipment can perform this operation as economically as an Eimco Tractor Excavator.

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CIVIL ENGINEERING

OCTOBER 1955
VOL. 25 • NO. 10

THE MAGAZINE OF ENGINEERED CONSTRUCTION

• ARTICLES

• SOCIETY NEWS

• NEWS BRIEFS

• DEPARTMENTS

TOPS for strength,

For jobs, where long life is a *must*, you can specify cast iron pipe with confidence. Confidence in its strength and toughness—its ability to withstand beam-stresses, traffic shock, compressive loads—its proved long life over a history running into centuries. The factors which endow cast iron pipe with its great durability are also the factors which mean negligible repairs and maintenance costs. When the job calls for *permanence*, specify cast iron pipe. For further information, write Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 So. Michigan Avenue, Chicago 3.

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Mechanical joint cast iron pipe being installed for gas main in Milwaukee, Wis.

CAST IRON PIPE

NEWS OF ENGINEERS

ASCE Member to Be President of ASME

Joseph W. Barker, M. ASCE, chairman and president of the Research Corporation, New York City, has been nominated next president of the American Society of Mechanical Engineers. Dean of engineering at Columbia University from 1930 to 1946, Mr. Barker served during the war as special assistant to the Secretary of the Navy in charge of all naval education and training policy, including the V-12 college training program. He will take office at the ASME's annual meeting in Chicago this fall.

New regional vice-presidents will be Charles E. Crede, Watertown, Mass.; Frank W. Miller, Philadelphia; Albert C. Pasini, Detroit; and Bryan T. McMinn, Seattle.

Laurence E. Anderson, member of the Los Angeles City College faculty, has been appointed chairman of the physics department there.

James W. Hall, president of the Hallmac Construction Co., specialists in pipeline construction, announces the relocation of its main office to 3701 Buffalo Drive, Houston, Tex.

Duane R. Keller, a research engineer from Seville, Ohio, becomes head of the civil engineering department at the University of Akron this September. Professor Keller has taught at the Universities of Alabama and Maryland. For the past year he has directed research on a guided-missiles project for the government at the Materials Analysis Laboratory at Redstone Arsenal in Huntsville, Ala.

Gershon Kulin recently joined the staff of the National Bureau of Standards where he will conduct experimental research in general fluid mechanics and hydraulics. His headquarters are in Washington, D.C. Dr. Kulin received his doctorate from M.I.T. this year while working as an engineering research assistant in the Hydrodynamics Laboratory there.

Channing L. Pao has resigned as research structural engineer at Blast Effects Research, Wright Air Development Center, Dayton, Ohio, to take the new position of vice-president and chief engineer for Abco Construction and Engineering Co. there.

Jerome K. Doolan, vice-president of the Bechtel Corporation, Los Angeles, Calif., has been elected a director of the Union Bank & Trust Company in that city.

J. Edward Johnston has resigned as manager of the Traffic Engineering Department of the American Automobile Association in Washington, D.C., to accept the position of highway transportation specialist for the U.S. Chamber of Commerce, with headquarters in the same city. Mr. Johnston was manager of the A.A.A. Highway Department before managing the traffic engineering division.

George S. Richardson announces the formation of a new partnership, Richardson, Gordon, and Associates, to be located in Pittsburgh. The new firm includes the offices of George S. Richardson, established in 1939; Richardson and Gordon, a partnership formed in 1951; and Richardson, Morehouse, Ramsey and Fisher, a partnership organized in 1952. Its new offices will be at 3 Gateway Center.

Harry S. Rogers, president of the Polytechnic Institute of Brooklyn, has been elected a director of the McGraw-Hill Publishing Co. of New York City.

Harry K. Gidley, director of the West Virginia Division of Sanitary Engineering and executive secretary of the West Virginia Water Commission, Charleston, is ending a 25-year career with the West Virginia State Department of Health to enter a consulting partnership with **W. D. Kelley** and **William S. Staub** under the firm name of Kelley, Gidley, and Staub. The new firm will have offices at 5418 McCorkle Ave., S.W., South Charleston, W. Va.

L. T. Wyly, who has been professor of structural engineering at Purdue since 1946, has resigned to accept a position as research professor of structural engineering at Northwestern University. **J. L. Waling,** until recently professor of engineering sciences at Purdue, has been placed in charge of structural engineering to succeed Professor Wyly.

Eric C. Molke, chief engineer of Prestressing Research & Development, Inc., San Antonio, Tex., is making a tour of Europe to study the latest design techniques in prestressed concrete bridges and buildings. He attended the Second International Federation of Prestressing, held in Amsterdam, Holland, the first week in September.

Ross C. Keeling, has resigned as chief engineer for the Kansas Highway Commission to join the consulting engineering firm of Howard, Needles, Tammen and Bergendoff, Kansas City, as project engineer on the Kansas Turnpike. **Walter G. Johnson** has been appointed the new chief engineer for the Kansas Highway Commission. He has been the head of the Secondary Roads Department for 10 years.

Lucius D. Barrows, chief engineer of the Maine State Highway Department at Augusta, has retired after forty-five years in the service of the state. When Mr. Barrows went to the department in 1910,

Lucius D. Barrows

Vaughan M. Daggett

it was only five years old. He has been chief engineer since 1928. Mr. Barrows will be succeeded by **Vaughan M. Daggett,** of Augusta, who has been assistant chief engineer since 1951.

Raymond Nen Yiu Yong, formerly associated with the Illinois State Highway Department, has joined the engineering staff of Soiltest, Inc., Chicago.

Robert J. McLeod, a member of the engineering department of the Washington (D.C.) Surburban Sanitary Commission since 1938, has been appointed as its deputy chief engineer. Mr. McLeod has been in charge of plans and surveys for the Commission since 1952.

D. W. Lewis, formerly research engineer for the Indiana Joint Highway Research Project and associate professor of highway engineering at Purdue University, has joined the National Slag Association as chief engineer. His headquarters will be Washington, D.C.

F. A. Dale is a visitor in Switzerland and neighboring countries investigating the latest European practices in the design of high head penstocks and turbines in connection with a hydroelectric project in the Far East.

Jack L. Staunton, chief sanitary, hydraulic, and petroleum engineer for the New York City firm of Seelye, Stevenson, Value & Knecht has been made an associate in the firm.

(*Continued on page 22*)

News of Engineers

(Continued from page 21)

P. B. Kirby has been appointed as chief engineer of the structural and civil engineering division for the firm of Albert Kahn Associated Architects and Engineers Inc., Detroit, Mich. Mr. Kirby was previously assistant chief engineer for the firm.

William L. Chilcote, Baltimore's deputy highways engineer and president of the Maryland Section of the Society, recently spent two weeks in California taking a course for Naval Reserve Officers in disaster relief.

William J. Bobisch has resigned as director of design, Eleventh Naval District, San Diego, and joined Moffatt & Nichol, Inc., Consulting Engineers, Long Beach, as one of the principals of the firm. Mr. Bobisch has been with the Eleventh Naval District since 1950.

William J. Bobisch

Linvil G. Rich, a member of the Commissioned Reserve, Public Health Service, U.S. Department of Health, Education and Welfare, has been called to active duty and assigned to the USA Operations Mission to La Paz, Bolivia. Dr. Rich is taking a year's leave of absence from the Virginia Polytechnic Institute at Blacksburg, where he is professor of sanitary engineering.

John J. Hammond, chief of the Bureau of Reclamation's Dams Branch in Denver, is retiring after thirty-five years of government service to open offices as an engineering consultant. Mr. Hammond has supervised the design of virtually every major concrete dam built by the Bureau, including Grand Coulee, Hoover, and Shasta Dams.

John C. Cobb, a federal road engineer in West Virginia for almost twenty years, has been named head of the Federal Bureau of Public Roads office in Kentucky. **C. L. Bower,** district bridge engineer in the Charleston office of the Bureau for West Virginia, has been named as his successor. Mr. Cobb's headquarters will be Frankfort.

W. Thomas Rice, president and director of the Richmond, Fredericksburg and Potomac Railroad, has been named head of Railroad Unit No. 2 in the Richmond Area Community Chest campaign this fall.

Miles M. Dawson, Brig. Gen., U.S. Army Corps of Engineers, is now the spare parts supply and stock control officer, with headquarters at Columbus, Ohio. General Dawson was formerly the engineer supply officer for the Columbus General Depot.

Amandus J. Schrauth was recently appointed village manager of Ardsley, N.Y. He has been supervising municipal water surveys in both Canada and the U.S. for Pitometer Associates of New York City

Earl L. Mosley, secretary-manager of the Denver Water Board, has been named as project engineer with the specific job of coordinating plans for the expenditure of $75 million in bonds.

Arthur P. Geuss has been appointed vice-president and chief engineer of the Harza Engineering Co., Chicago. In the same firm, **C. K. Willey** has been made vice-president and Western manager.

I. E. Morris announces that the name of the firm has been changed from I. E. Morris & Associates to Morris, Boehmig & Tindel, Inc. Headquarters for the firm will be in Atlanta, Ga.

Harry S. Riddell, of Yuma, Ariz., is retiring after fifty years of irrigation engineering in Washington, California, and Arizona. Most recently Mr. Riddell has been project manager of the Yuma County Water Users' Association.

Bartow Van Ness, Jr., former chief engineer of Pennsylvania Water & Power Company, Baltimore, has been appointed assistant mechanical engineer in the Pennsylvania Power and Light Company.

A. D. Edmonston is retiring as California State Engineer. Mr. Edmonston has been in the service of the state for many years with headquarters in Sacramento.

New Publications

Waterways Experiment Station . . . Three recent publications from the Waterways Experiment Station outline investigations conducted by the Corps of Engineers. A hydraulic model and prototype investigation of Tainter Gates at Norfork Dam in Arkansas is reported in Technical Memorandum No. 2-387; tests for determining the holding strength of anchors for securing cantilever forms to mass-concrete surfaces are described in Technical Memorandum No. 6-399; and problems involved in providing pressure-measuring apparatus required for field use are discussed in Bulletin No. 40. Copies are priced at $1.00, 50 cents, and 75 cents, respectively, and may be obtained from the Waterways Experiment Station, Vicksburg, Miss.

Thin concrete shells. . . Proceedings of the conference on thin concrete shells, held at M.I.T. in June 1954, have been edited by Myle J. Holley, Jr., and Howard Simpson and are available from the Institute. Sponsored jointly by the Department of Architecture and the Department of Civil and Sanitary Engineering, the Conference was called to stimulate interest in thin concrete shells and provide an opportunity for reviewing recent developments in the field. One day was devoted to each of the following: Architecture, Structural Analysis, and Design and Construction. Inquiries should be addressed to Massachusetts Institute of Technology, Cambridge, Mass.

Highway Personnel directory. . . Issuance of the 1955 edition of its pocket-sized directory of "Highway Officials and Engineers" is announced by the American Road Builders Association. The handy reference work includes more than 1,500 names, titles, and addresses of administrative engineers and officials in all the state highway departments; administrative personnel of the Bureau of Public Roads, toll road authorities, and the ARBA; and a tabulation by states of highway funds expended during 1954 and of estimated 1955 needs. Copies, priced at $1 each, may be obtained from the ARBA, World Center Building, Washington 6, D.C.

Education . . . "Elementary and secondary education and the survival, strength, and growth of the United States" was the general theme of the Fifth Thomas Alva Edison Foundation Institute, held in October 1954 under joint sponsorship of the Engineering Manpower Commission of EJC, the Scientific Manpower Commission, and the Thomas Alva Edison Foundation. The Proceedings of the three-day program, which touched on many aspects of scientific and technological education, including the manpower shortage, are now available from any of the three sponsoring organizations. The Engineering Manpower Commission has its headquarters at 29 West 39th St., New York 18; the Scientific Manpower Commission at 1530 P. St., N.W., Washington 5, D.C.; and the Thomas Alva Edison Foundation at Main St. and Lakeside Ave., West Orange, N.J.

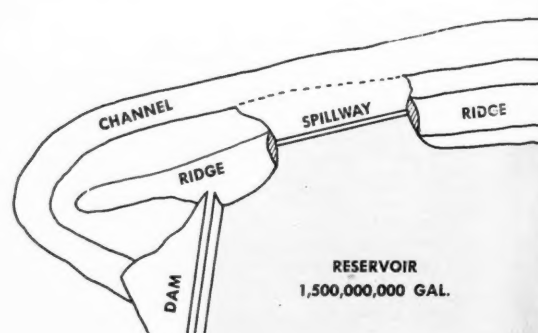
Welded wire reinforcement . . . Use of welded wire fabric in reinforced concrete building construction is covered in a 44-page design manual prepared by the Wire Reinforcement Institute, Inc. The illustrated bulletin includes comprehensive design data and recommendations on many applications of fabric in concrete, such as shortspan construction, cinder concrete floors and roofs, and tilt-up construction. Free copies are available from the Wire Reinforcement Institute, Dept. 50, 1049 National Press Building, Washington 4, D.C.

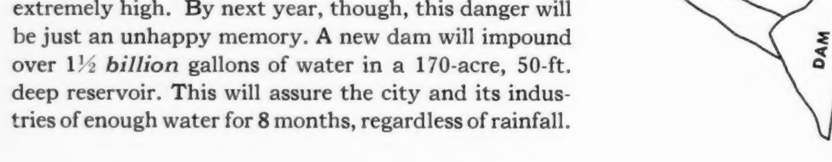
Defense materials . . . Publication of a handbook on the defense materials system is announced by the Business and Defense Services Administration of the U.S. Department of Commerce. The 41-page booklet—entitled "The Defense Materials System in Our American Industry"—stresses the need for a "functioning materials control system designed to permit industrial mobilization in case of war." Copies may be purchased from the Superintendent of Documents, Government Printing Office (Washington 25, D.C.), and Department of Commerce field offices at 25 cents each.

Water and sewerage construction . . . The cost of the 1,569 water and sewerage projects remaining to be completed under two programs financed by government funds at present prices would approximate $1 billion, though their cost was originally estimated at $620 million, according to a bulletin made available by the Department of Commerce. The publication—entitled "Estimated Water and Sewerage Construction Costs of Projects Remaining in the Advance Planning of Non-Federal Public Works Program"—presents, by cities, a break-down analysis of each of the active projects not yet constructed. Copies are for sale by the Department of Commerce, Washington 25, D.C., and its field offices, at 20 cents each.

Steel products . . . Issuance of three new sections of its Steel Products Manual, a continuous compilation covering the major steel products, is announced by the American Iron and Steel Institute. The present sections deal with "High Strength Low Alloy Steel (45 pages); "Tool Steels" (72 pages); and "Railway Track Materials" (93 pages). Inquiries should be sent to the Institute at 350 Fifth Ave., New York 1.

A year ago the work area you see above was the site of a near-disaster. Due to prolonged drought, the 50-million gallon reservoir which supplied Sylacauga, Ala. became completely emptied. For 3½ months, 15,000 people were forced to rely on tank trucks and a nearby spring for their water. Textile, foundry, and quarry industries had to cut production. Fire danger was extremely high. By next year, though, this danger will be just an unhappy memory. A new dam will impound over 1½ *billion* gallons of water in a 170-acre, 50-ft. deep reservoir. This will assure the city and its industries of enough water for 8 months, regardless of rainfall.





Location of the dam is between two hills at a bend in a winding stream channel. Being built over the concrete spillway of the old dam, the new structure will be 815 ft. long and 75 ft. high.

Its base will be 353 ft. wide; its top berm, 15 ft. Some 215,000 yds. of compacted clay will form the core; 13,000 tons of native marble, the rip-rap face.

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- Precisely fabricated panels make installation easier, faster.
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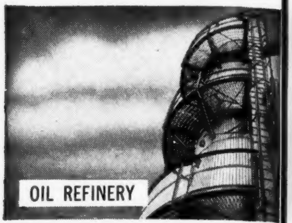
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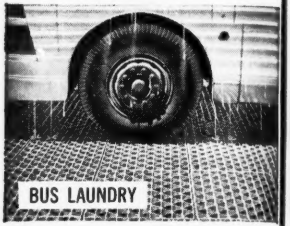
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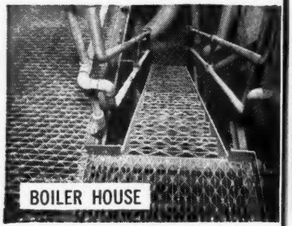
Strong; self-draining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RECENT BOOKS

The Bomb, Survival and You—Technical Supplement

The main volume, published in 1954, dealt in a non-technical manner with the effects of atomic blasts. This supplement, intended for structural engineers concerned with such blasts, presents a mathematical analysis of a fixed-end one-way reinforced concrete slab which may be strained to any degree short of complete fracture, and in which speed of loading is of importance. Fred N. Severud and Kurt Bernhard are the authors. (Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N.Y., 1955. 45 pp., $2.50.)

Engineering Mechanics

This comprehensive treatment of the usual topics in engineering mechanics features maximum use of the free-body diagram approach and emphasizes the principles employed in the solution of problems. In this edition, by Archie Higdon and William B. Stiles, a number of chapters have been reorganized, a chapter on the use of virtual work in equilibrium has been added, and about forty percent of the problems have been replaced. (Prentice-Hall, Inc., 70 Fifth Avenue, New York, N.Y., 2nd edit., 1955. 585 pp., $7.95.)

Reinforced Concrete and Prestressed Concrete Structures

Descriptions of industrial and commercial buildings and bridges designed by the author, Riccardo Morandi, mainly between 1950 and 1953. The text is in parallel columns of Italian and English. (Libreria Dedalo, Rome-distributed in U. S. by W. S. Heinman, 400 East 72nd Street, New York 21, N.Y., 1954. 141 pp. $10.)

Strength of Materials

Part I: Elementary Theory and Problem

The third edition of this standard work by S. Timoshenko has been expanded by the addition of two new chapters, one on the bending of beams in a plane which is not a plane of symmetry, the other on the bending of curved bars. A number of minor changes have been made throughout the book, and new problems have been added. (Van Nostrand Company, Inc., 250 Fourth Avenue, New York 16, N.Y., 3rd edit., 1955. 442 pp. $6.00.)

Die Wiederhergestellte Autobahnbrücke über den Rhein in Rodenkirchen bei Köln

A detailed description of the design and construction of an 1860-ft suspension bridge with unusual features such as a prestress "constructed" into the steel stiffening girders and a concrete roadway built as an integral part of a composite concrete and steel floor system. The book is an official publication of the West-German Ministry of Transportation. (Springer-Verlag, Berlin, 1954. 92 pp., DM 18.00.)

Schleusen und Hebewerke

A treatise by Hans Dehnert on the planning, design, construction, and operation of ship locks on canals and rivers. Detailed discussions, calculations, and sketches covering a wide range of practice and actual installations, mostly European, are fully described, including several unusual types such as those in which both water and ship are lifted and lowered. (Springer-Verlag, Berlin, 1954. 340 pp., DM 45.00.)

Book of ASTM Standards Including Tentatives, 1954 Supplement

Part I: Ferrous Metals. II: Non-Ferrous Metals. III: Cement, Concrete, Ceramics, Thermal Insulation, Road Materials, Waterproofing, Soils. IV: Paint, Naval Stores, Wood, Cellulose, Wax Polishes, Sandwich and Building Constructions, Fire Tests. V: Fuels, Petroleum, Aromatic Hydrocarbons, Engine Antifreezes. VI: Rubber, Plastics, Electrical Insulation. VII: Textiles, Soap, Water, Paper, Adhesives, Shipping Containers. These supplements in their latest form give 415 specifications, tests, and definitions which were either issued for the first time in 1954 or revised since publication in the 1952 Book of Standards or 1953 supplements. (American Society for Testing Materials, 1916 Race Street, Philadelphia 3, 1954. 7 volumes, $3.50 ea.)

Les Charpentes en Bois

A detailed treatment by Yves Gasc and Robert Delporte of heavy wood construction covering roof and girder design, normal framing practice, prefabricated units, and modern connectors and jointing methods. Introductory chapters describe the properties of wood and traditional framing methods. (Éditions Eyrolles, Paris, 1954. 332 pp., F frs. 2400.00.)

Structural Analysis

The Solution of Statically Indeterminate Structures

This text by W. Fisher Cassie for students already familiar with the theory of structures develops the following methods: area moments, strain energy, slope deflection, moment distribution, influence lines, and the column analogy. A new chapter containing notes on the use of flexible models has been added to this edition. (Longmans, Green and Company, Inc., 55 Fifth Avenue, New York 3, 2nd edit., 1954. 269 pp., $3.50.)

Symposium on Lateral Load Tests on Piles, and Supplement

Special Technical Publications 154 and 154-A

The ten papers included in these ASTM pamphlets have been published with a view to standardizing procedures for tests of this type. The papers report results of tests made on various types of piles under different methods of loading and in many kinds of soil conditions. (American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1954, 1955. 101 pp., 44 pp., $2.75 for both—154-A, $1.00.)

Steel Designers' Manual

Advance methods as applied to modern steel framed buildings are presented, along with complete data, tables, and diagrams for use by the practicing designer. Included are sections covering theory, design, and deflection of beams; modern methods of structural analysis; bunker and hoppers; beams in torsion; foundations; plate girders; properties of sections; analysis of single bay, single story rigid frames; and many other topics. A minimum amount of higher mathematics is used, and many worked examples are included. Charles S. Gray is the principal author. (Frederick Ungar Publishing Co., 105 East 24th Street, New York 10, N. Y., 1955. 909 pp., $12.50.)

Steel Structures Painting Manual

Volume 2: Systems and Specifications

This second volume edited by Joseph Bigos contains specific recommendations for the painting of various types of steel structures, supplementary to the general recommendataions of good practice included in the first volume. It consists mainly of specifications for surface preparation, pretreatment, paint application, paints, and complete paint systems, compiled as a guide to those

(*Continued on page 28*)

Recent Books

(Continued from page 27)

with only a limited knowledge of painting and as a checklist of good practices for those experienced in the painting of steel. (Steel Structures Painting Council, 4400 Fifth Avenue, Pittsburgh 13, Pa., 1955. 292 pp., $6.00.)

Taschenbuch der Stadtentwässerung

A concise and authoritative reference work by Karl Imhoff for engineers on all aspects of municipal sewerage. The first section on sewer design contains many graphical aids for simplified calculations. The second, and larger, section gives detailed information on methods of sewage treatment. Over 600 references to both German and English-language publications are given in the text. (R. Oldenbourg, Munich, 15th ed., 1954. 335 pp., D.M.14.00.)

Waterhammer Analysis

Although primarily a textbook for graduate and undergraduate courses, an attempt has been made to meet the needs of practicing engineers. The rigid and elastic water column theories, velocity of water hammer waves, and water hammer wave reflection are dealt with in the opening chapters. Later chapters cover a wide range of problems such as water hammer for rapid and slow gate movements, analysis for compound pipes, surge tanks, and others. Results of many types of analysis are presented in graph form. John Parmakian is the author. (Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y., 1955. 161 pp., $6.50.)

Cours de Résistance des Matériaux

An introduction by J. Courbon to strength of materials for practicing engineers as well as for students. The major part of the book is devoted to the theory of both statically determinate and statically indeterminate beams and arches approached by various methods. Problems of elastic stability, thin plates, slabs, and suspension bridges are considered. (Dunod, Paris, 1955. 782 pp., F frs. 7400.)

The Welland Canal Company

This book by Hugh G. J. Aitken is concerned chiefly with the company formed to carry out the project, and with problems of promotion, construction, finance, and management during the years 1818–1843. Considerable emphasis is placed on the roles of William H. Merritt and the other men responsible for the construction of the canal. (Harvard University Press, Cambridge, Mass., 1954. 178 pp., $3.50.)

Vorträge der Baugrundtagung 1953

Deutsche Gesellschaft für Erd- und Grundbau

Nine papers presented at a Foundation Soil Conference deal with special aspects of design and construction procedures, with unusual soil conditions, or with settlement problems; one paper discusses examples of geological engineering foundation maps. The Conference was sponsored by the German Society for Earthwork and Foundation Engineering. (Wilhelm Ernst und Sohn, Berlin, 1954. 191 pp., DM 18.00.)

Die Versuche der Bundesbahn an Spannbetonträgern in Kornwestheim

Deutscher Ausschuss für Stahlbeton, no. 115

A report of fracture tests by the German Federated Railroads on reinforced concrete beams, giving detailed information on the test pieces and the method of testing, and a summary of the test results including graphs and tabulations. U. Giehrach and Ch. Sättele are the authors. (Wilhelm Ernst und Sohn, Berlin, 1954. 33 pp., DM. 10.00.)

do you know that

This is our twenty-fifth anniversary? In October 1930 the first issue of CIVIL ENGINEERING was mailed to the Society's 14,366 members. This issue will go to 39,167 members and will have a commercial sale of some 5,000 copies. The first issue had 68 pages—eight of them advertising pages. The average today is 132 pages, including about 65 pages of paid ads. This anniversary issue brings you 200 pages.

The first issue of "Civil Engineering" set a good pace? Elwood Mead, Commissioner of Reclamation, was lead author with an article on Hoover Dam, the great project of the day. There was a photo of cable compaction for the great bridge project of the day—the Fort Lee Bridge, known now as the George Washington Bridge. Arc welding, then in its infancy, was recognized in an article by Frank P. McKibben, consulting engineer for General Electric. The professional preoccupations of the first issue remain our professional preoccupations—the status of the engineer, salary studies, an engineer's obligation to a former employer, the subject of fees.

A lot of editorial spade work preceded the first issue? Prominent in the planning were the late George T. Seabury, Secretary of the Society; Carl E. Beam and Sydney Wilmot, now retired from the Society's staff; and Harold T. Larsen, now manager of Technical Publications. Walter E. Jessup was the first editor, and Donald D. King, now editor of *Construction Equipment*, was production manager.

Construction today is at an all-time high? Outlays for new construction continue at peak level, bringing the total for the first eight months of the year to $27.1 billion, which is at an annual rate of an unprecedented $41 billion. The Departments of Commerce and Labor are the source of these estimates. In 1930 construction was dropping sharply from its postwar boom heights, and outlays for the whole year were only $8.7 billion.

Work will start soon on a new ASCE Membership Directory? The coupon for reporting your correct address for this listing will appear in an early issue. In 1930 a 528-page Year Book was issued to every member at a total cost of $6,900. The combined cost of today's 728-page Membership Directory (issued biennially and in limited edition) and an Annual Register is about $32,000.

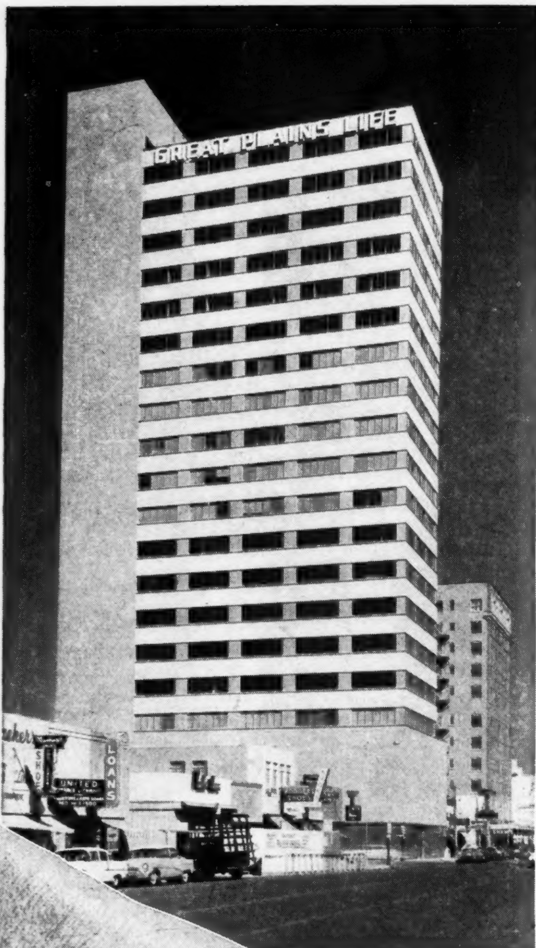
The entire Ohio Turnpike is now open to traffic? On October 1 the entire 241 miles of the Ohio Turnpike went into service. This new high-speed toll road, with the existing 360-mile Pennsylvania Turnpike, makes it possible for motorists to travel from the Delaware River to the Ohio-Indiana line without being stopped by a single traffic light. In September 1930, motorists were rejoicing that the recently opened Holland Tunnel and Pulaski Skyway had reduced the New York-Philadelphia trip from an all-day expedition to a three-hour drive. Turnpikes, in the modern sense, were undreamed of.

The Empire State Building was under construction in 1930? This lofty structure remains the tallest building in the world and one of the largest, exceeded in floor space only by Chicago's Merchandise Mart and the Pentagon.

Formation of a Pipeline Division is being considered? The Construction Division's popular Committee on Pipelines would like to achieve Technical Division status if enough members are interested (page 128). If it does, the Society will have fourteen Technical Divisions. In September 1930 there were only nine—City Planning, Construction, Highway, Irrigation, Power, Sanitary Engineering, Structural, Surveying and Mapping, and Waterways—all set up in the twenties.

The shortage of engineers continues to be critical? In the first eight months of this year the Engineering Societies Personnel Service has had 6,706 positions to be filled and only 3,162 engineers to fill them. In the whole of 1930 it registered 3,825 engineers seeking jobs and had only 2,986 positions to be filled. Many of the jobs listed were poor (temporary, part-time, made-work) as well as scarce, the E.S.P.S. says, a portent of the depression to come.

A more spectacular quarter of a century is in store for us? The U.S. Chamber of Commerce foresees atomic-powered automobiles, trucks, and locomotives; passenger-carrying space rockets circling the globe; tranportation centers coordinating rail, air, and bus facilities; terminals and hangars with vast areas of unobstructed floor space roofed with thin-shell concrete arches spanning 500 feet without intermediate support. These are a few of the predictions in a new Chamber of Commerce film, "People, Products and Progress, 1975."



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Masons are always pleased when they see Lone Star Masonry Cement on the job. They go for its rich, smooth plasticity, the way it carries sand, the ease with which it works under the trowel and spreads to a smooth bed and full joint.

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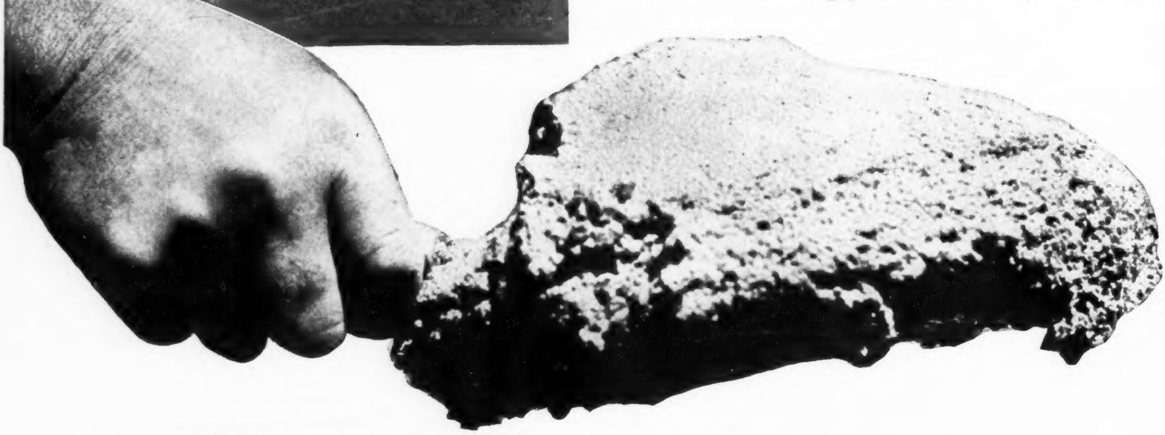

GREAT PLAINS LIFE INSURANCE BUILDING
General Contractor: **B M F P CONSTRUCTION CO**
Architect: **DAVID S. CASTLE**, Abilene

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CIVIL ENGINEERING 1930-1955

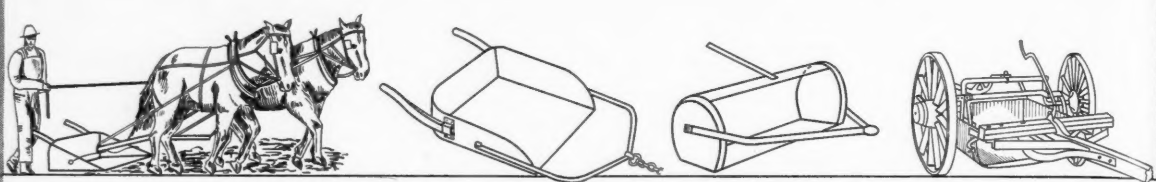
ENGINEERING'S GOLDEN AGE

It has been a quarter century of superlatives—a quarter century in which we have built the tallest, longest, largest, deepest structures in history. The frontiers of engineering science have been vigorously explored, and the inventiveness of our constructors has known no bounds. More dollars have been spent on engineered construction in this period than in any previous twenty-five-year period. In 1930, 8.7-billion-dollars' worth of new construction was put in place. By 1955, this figure had reached 42 billion dollars annually.

These characteristics of size and volume have had a significant effect on design practice and construction techniques. With the pressures of speed and the greatly enlarged scope of engineering contracts, engineering offices have grown from small one-man establishments to firms employing hundreds of designers, specialists, and technicians. Construction companies now have millions of dollars invested in machines of enormous capacity and specialized function. Diesel power has replaced animal power, and the amounts of material that can be handled by one man have soared.

And yet with all this increased capacity to build things, the backlog of work to be done keeps mounting. The demands for engineering services continue to exceed our capacity to provide them, and the nation's demand for higher living standards seems insatiable. Our population is growing at the rate of a city a day, creating a tremendous demand for new homes and community services. Each year more and more automobiles crowd our highways so that the 4.5 billion dollars spent annually on them is not enough to provide adequate facilities. As industries and communities grow, the problems of safeguarding public health are compounded. The factors behind such huge expenditures for engineering works and large-scale construction apparently will continue to exist for years to come. We can expect to see more big specialized machines on the job. Prefabrication will assume a more and more prominent place in all phases of construction. Production per man-hour will continue to rise. If present calculations are correct, the demand for engineering services will continue to grow for a long time.

We are on the threshold of the Golden Age of Engineering. Professionally we have lived up to the almost fantastic demands of our times, but we must retain our intellectual vitality, vigor and alertness if we are to keep faith with the future.



2 hp slip scrapers, $15 — 4 hp Fresno, $80 — Western wheeler, 1870-1920, $250

FIG. 1. THE SCRAPER FAMILY AND ITS

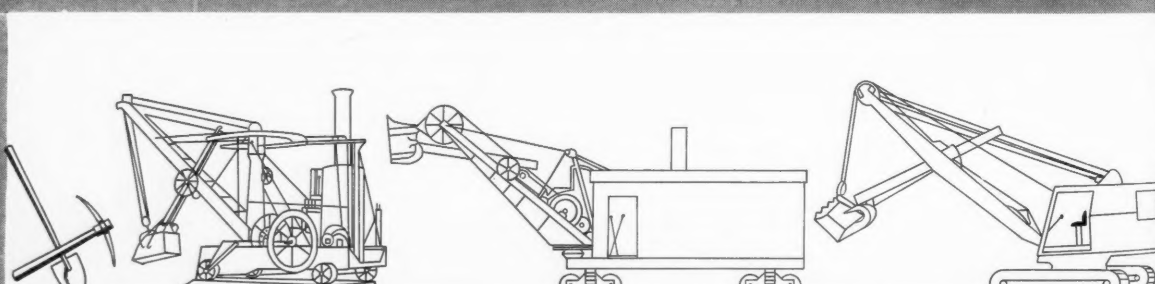
A construction engineer

J. G. TRIPP, M. ASCE

With the exception of aeronautics, few industries have matched the construction industry in the development of "tools of the trade" in the past forty years. However, present-day heavy construction equipment involves no new principles. The lion's share of credit goes to the mechanical and metallurgical engineers, spurred on by the insistent demands of contractors for money-saving tools to offset the incessant demands of labor, taxes, and other mounting costs. The impact of war hastened the process.

The greatest advances are found in modern excavation and earth-moving equipment. The ancestral two-mule slip scraper (Fig. 1), the four mule Fresno, and the two-mule wheeler have evolved as the twin-engined, 400-hp, 23-cu yd Tournapull, a trade name honoring Le Tourneau, who invented this type of machine—a great advance in earth-moving tools. The horse-drawn stick wagon has evolved into the modern heavy-duty dump truck. The standard track-mounted, semi-revolving steam shovel of early railroad days (Fig. 2) sired the modern crawler-mounted, full-revolving shovel and dragline, with capacities ranging from $^1/_4$ to 60 cu yd, powered by gasoline, diesel, or electric engines or even by steam.

The amazing result of all this inventiveness is that the contractors' total unit costs (not their bids) in broad outline are practically the same as they were forty years ago, technological and unit-volume savings having been absorbed by increases in wages, costs of materials, and social and capital costs. This condition is particularly true in hard-rock tunnel work. Nonetheless, in many instances, contractors' inventiveness and the



Ancestors, 2\frac{1}{2}$ — 1837 Otis, $4,500 — 1905 railroad shovel, $18,000 — Modern Marion, $35,000-$210,000

FIG. 2. THE SHOVEL FAMILY AND

MRS scraper, $34,000 — AC scraper, $12,000 — Tournapull, $18,000-$30,000 — Two engined Euclid, $50,000

ANCESTORS AND POWERED DESCENDANTS

talks about the tools of the trade

Consulting Civil Engineer, New York, N.Y.

cooperation of manufacturers have resulted in quick profits—but not for long.

However, the contractor's capacity to accomplish units of work has been multiplied many fold by his modern tools. Also his requirement for capital has multiplied until today he needs more than a span of mules and a great desire to prosper.

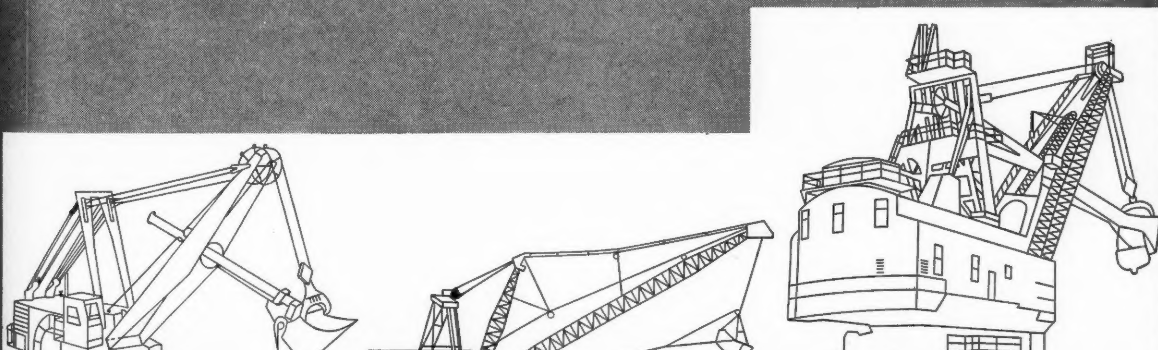
Concurrent with increased capacity of equipment has come the age of immense projects. The proper application of the "tools of the trade" now measures the modern contractor's ability to survive as well as to succeed.

The speed with which new inventions have come has its dangers too. Specialty tools such as loaders (Fig. 3) are appearing almost daily. Many improvements in tool design bring side effects such as are common in specific medicine and antibiotics. The modern contractor must select his tools with care based on knowledge. He must know them all and be prepared for a "lemon buy" now and again.

In keeping with the purpose of this article, the illustrations of equipment are accompanied by estimated prices. In the case of modern equipment, these are the 1955 f.o.b. factory prices. A glance at these prices, running from one dollar to $2,500,000, makes it evident that production per unit of time has been increased proportionately. Obviously no one will buy a 60-cu yd shovel for stripping unless money can be made by its use. The buyer of such a shovel had better have enough material to move so that he can write off the machine's cost in, say, five years, or some relevant tax period.

Equipment selection—an art

Selection of equipment is an art in-



Manitowoc $5\frac{1}{2}$ cu yd, $200,000 — Walking drag-line, 30 cu yd, $1,800,000 — Stripper, 60 cu yd, $2,500,000

ITS GROWN-UP DESCENDANTS

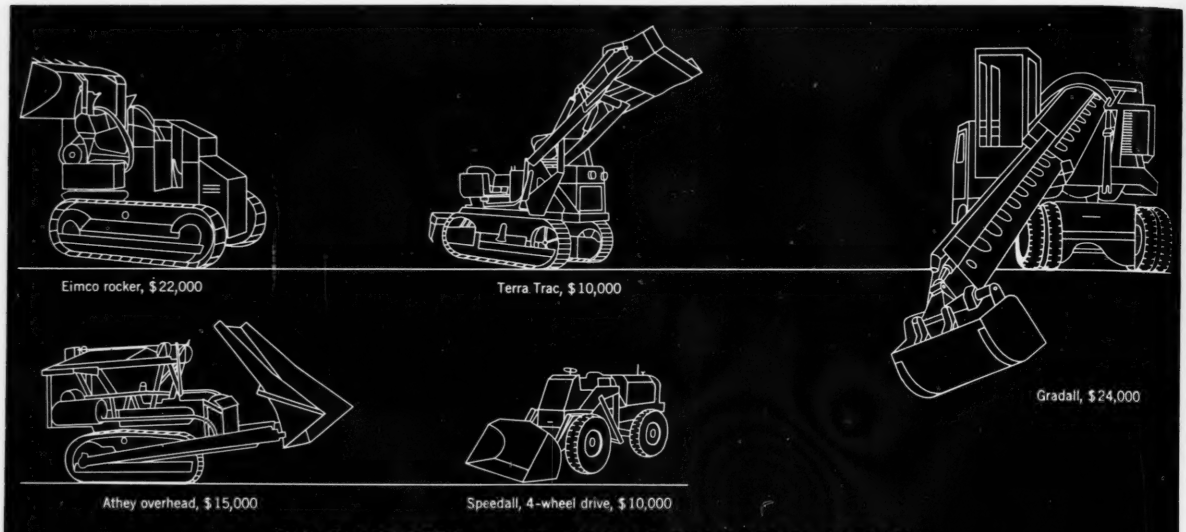


FIG. 3. LOADERS – A BRANCH OF THE SHOVEL FAMILY

volving judgment, based among other things on kind of work, types of labor available, capital requirements, costs of maintenance, repairs, power fuels, and last but not least, salvage values.

Let us assume that the work is earth moving and that bulldozers can do the job without haul. The selection of size of machine is then a matter of judgment. There are several standard makes and sizes on the market. Total costs will vary from $3^1/_2$ cents to 15 cents per cu yd moved. The variables are so great, however, that only a detailed analysis of a specific job will yield a dependable estimated cost.

In earth moving generally, when the distance between the cut and the dump is over 200 ft, scraper units should be chosen. Modern scrapers can be used economically on a one-way haul up to 3,000 ft. Hauls over this distance usually require truck units. The trucks can be loaded with shovels, draglines, front-end and overthrow loaders. The shovels may require bulldozers to pile up material from the cut above or from the loading floor, and also to maintain the pit and haul roads. On long hauls, the roads will be better maintained by motor graders. Sketches of these basic earth movers are shown in Figs. 4, 5, and 6, together with the ancestors of all of them, a proof of the statement that little is new in principle.

If the power units on all equipment on a particular job can be standardized by using one manufacturer's engine for all units, substantial savings in repairs and service can be effected.

Rock excavation requires drilling equipment, drill rods and bits, air compressors, explosives, loaders or shovels, bulldozers, trucks, and motor graders for haul roads. Rock excavation for road and quarry work generally requires wagon drills, churn or rotary drills, jack hammers, and related equipment. Several sizes and types are illustrated in Fig. 7.

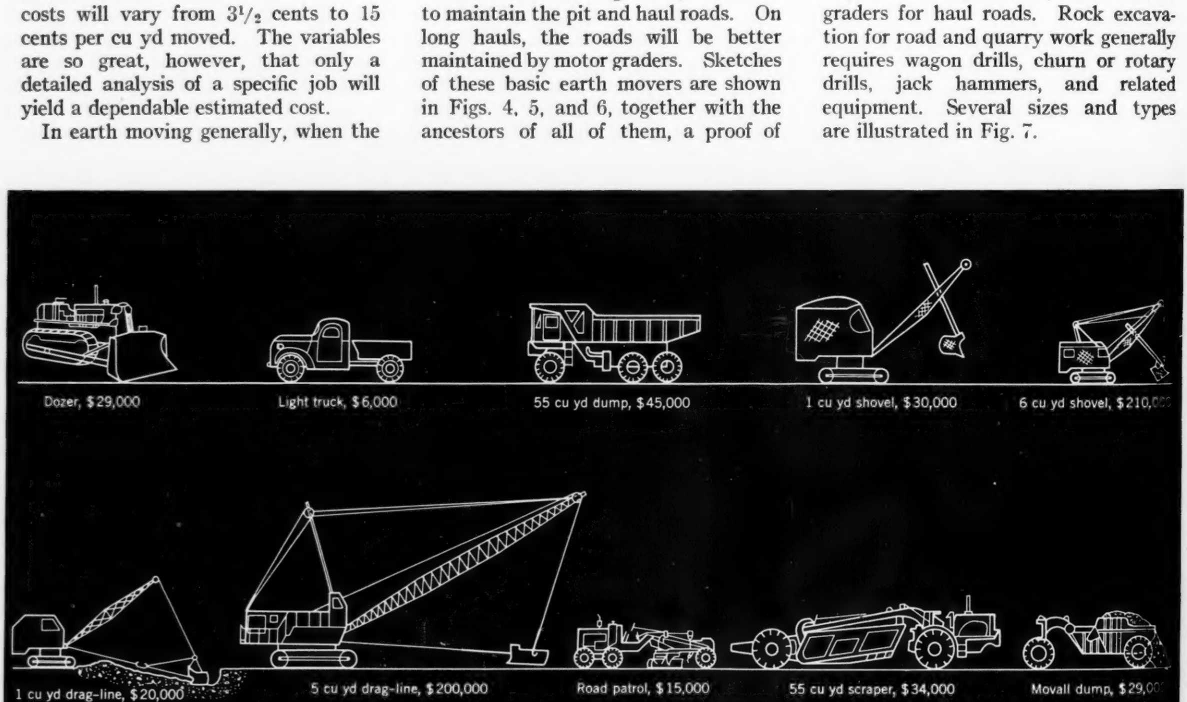


FIG. 4. THE BASIC EARTH-MOVERS

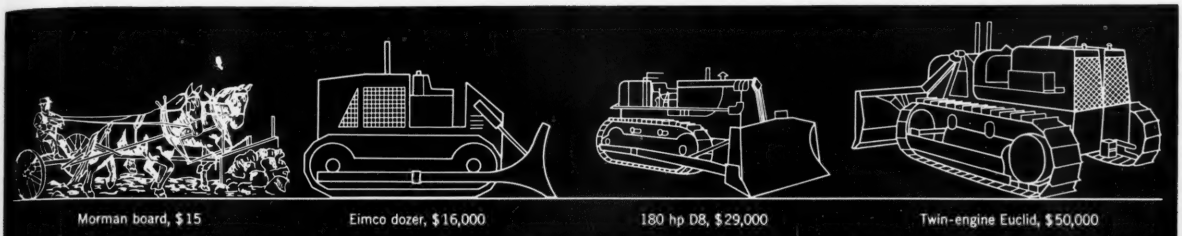


FIG. 5. BULLDOZERS AND THEIR PROGENITOR

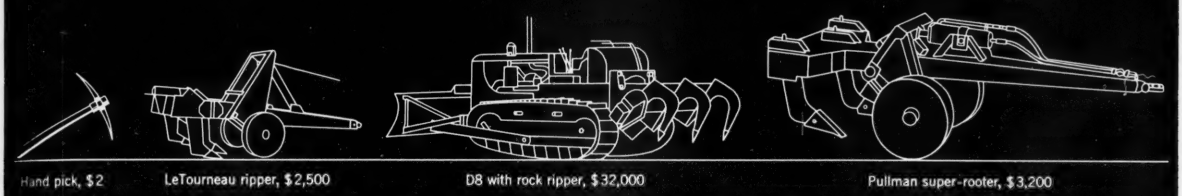


FIG. 6. THE PICK FAMILY GROWS UP

Different types of rock require different treatment. For instance a granite or limestone quarry for concrete aggregate, road metal, or rock fill will require different tools for quarrying, depending on the lay of the rock, height of quarry face, particle shape and size desired, and degree of abrasiveness. Excavation and loading of the blasted rock demands about the same tools as earth work, with special attention to hauling and digging units designed for the rigorous conditions always encountered in rock excavation. The modern torque converter is useful in minimizing shocks to operating parts. However, fuel consumption may be substantially higher. Abrasive-resistant metals are essential, and metallurgy is again basic to success.

Crushing, screening, and in many instances sand making, are ancient arts, but modern equipment has added something new—cubical grain shape for concrete aggregate. Crushing and screening of road material is done today on the job with semiportable and fully portable outfits such as are illustrated in Fig. 8. Costs for crushing and screening only are about 35 cents per ton of material.

Large concrete projects such as dams, airports, runways, and highways usually require centralized setups ranging in capacity from 1,000 to 10,000 tons per 8 hours.

Paving, whether asphaltic or concrete, requires aggregates processed by the equipment illustrated in Fig. 9. Laying or placing these materials requires other machinery, also shown in Fig. 9.

Concrete batching and mixing plants are in use all over the world. The commercial ready-mix plant is arranged to handle aggregates and cement delivered to it by crane, derrick, inclined belt, and cement elevator. Cement silos and screw conveyors are also needed. Batching can be manual or automatic. Dry batching and mixer trucks (Fig. 10) are usually employed for city jobs.

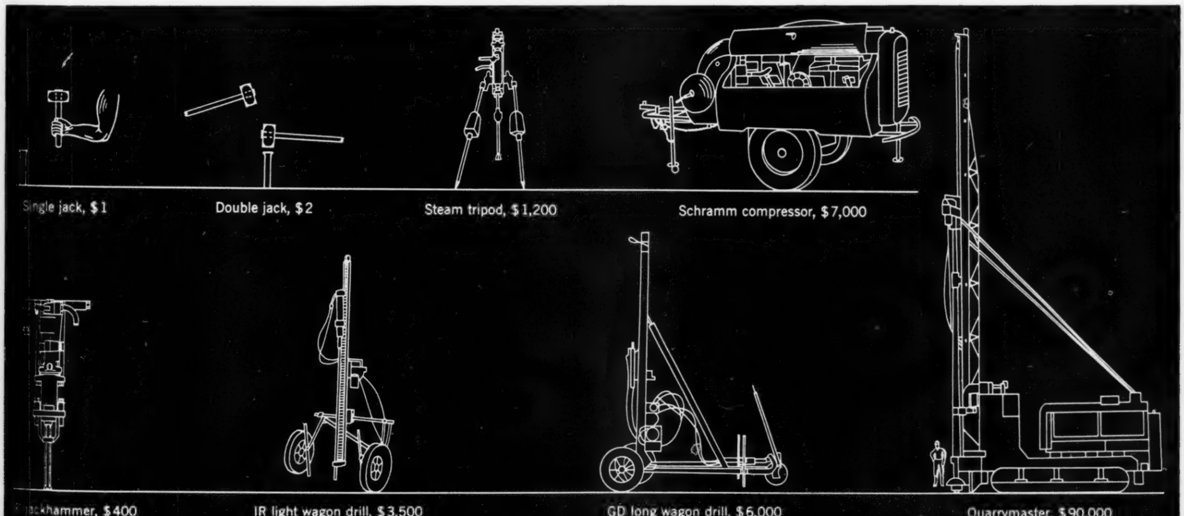


FIG. 7. THE DRILL FAMILY – ANCESTORS AND PROGENY

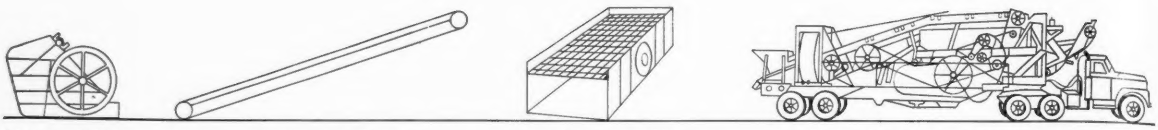


FIG. 8. ELEMENTS OF A PORTABLE AGGREGATE PLANT

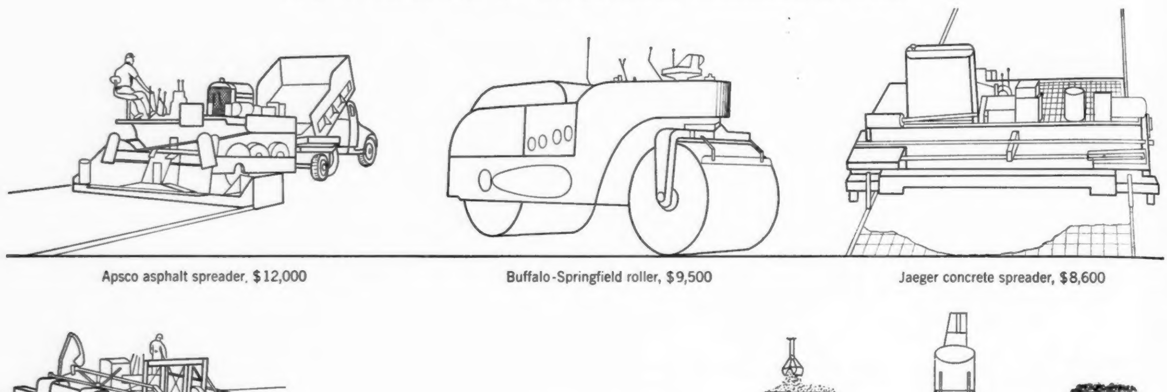
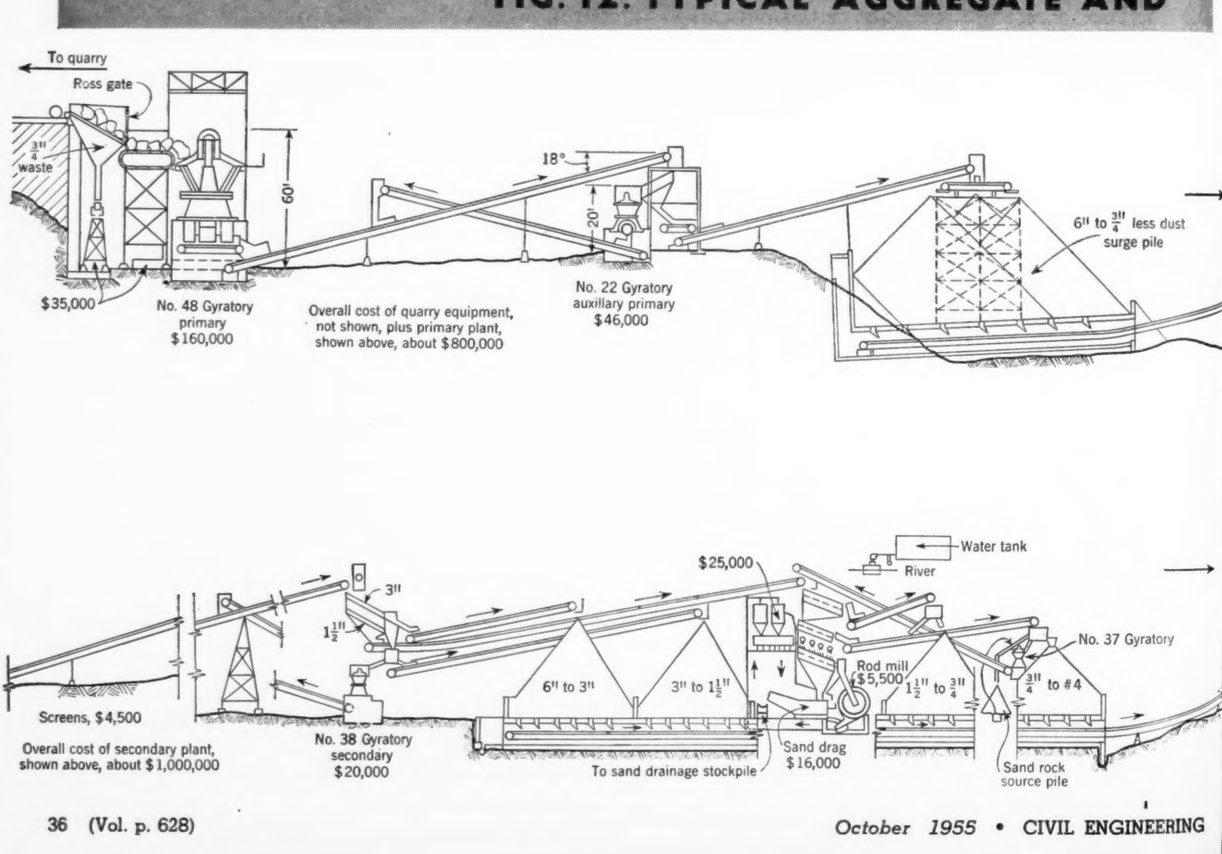


FIG 9 MACHINES FOR ASPHALT AND CONCRETE PAVEMENTS

FIG. 12. TYPICAL AGGREGATE AND



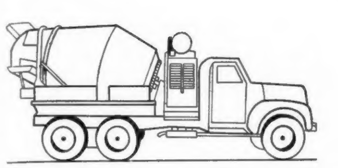


FIG. 10. **Transmit-mix trucks, in general used to haul wet concrete for city jobs, cost from $16,000 to $26,000.**

For paving, dry batching in batch trucks and paving mixers are in general use. Plant-mixed, dry-batched concrete hauled in Dumpcrete trucks (Fig. 11), is coming into general use on large jobs. The choice of any method is usually dictated by the contractor's equipment inventory and the kind and degree of training of his regular staff.

Concrete plant for large dams

In the case of large batching and mixing plants, getting the bins fed with aggregates, water, admix, and cement involves many kinds of gear. Control of batching and mixing, concrete cooling, and getting the concrete into the forms involve many additional kinds of machinery.

The illustrations already referred to have attempted to give an idea of some of the basic "tools of the trade." Only mention can be made of such specialized equipment as tunneling machines, concrete buckets, vibrators, pile drivers, and accessory equipment. It can be said that in them nothing is new in principle.

As for modern pile driving, it is simply the application of a driving force by air or steam, which in ancient times was applied by a drop-weight actuated by hand power.

The application of modern equipment to a specific project can be best illustrated by describing the flow-line diagram of materials and the arrangement of equipment for the construction of a large concrete dam (Fig. 12). Selection of the equipment for quarrying, crushing, screening, sand making, handling and cooling aggregate, and for mixing, hauling, and placing the concrete, involves all that has been said before about equipment choice and application. In addition, only choice of equipment sizes and design of the flow line for economic operations are required. The latter is a serious civil engineering job which includes such tasks as the design of the foundation and structural support for the machines, and the distribution of electric power to them.

Neither the quarry nor the quarrying equipment is shown in Fig. 12. Drilling and blasting methods are usually based on a combination of several factors: the character of the rock in the available quarry; selection of drilling tools to suit quarry conditions; selection of the proper type of explosives; and the contractor's know-how. Quarry rocks vary tremendously in character, from broken lavas to heavy traps and granites.

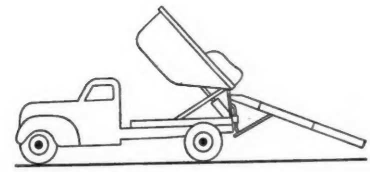
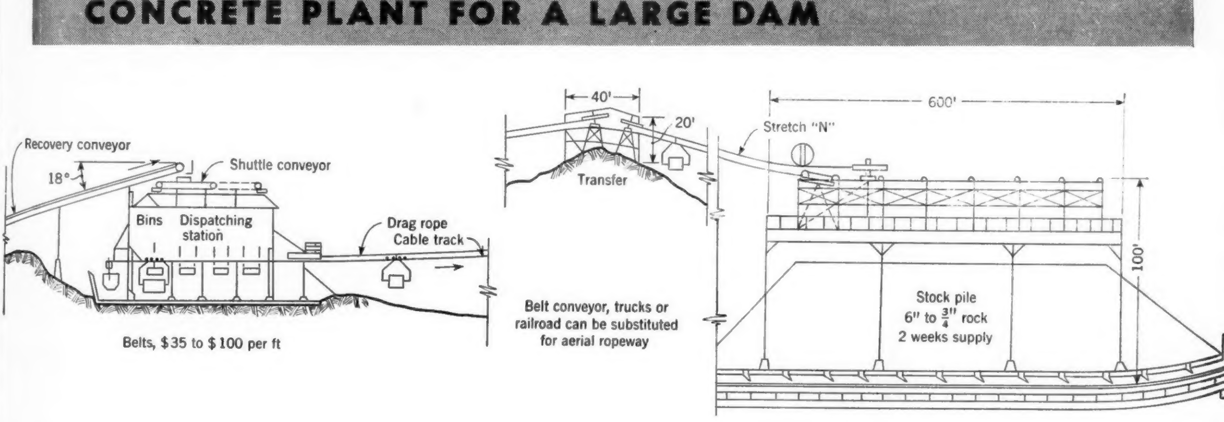
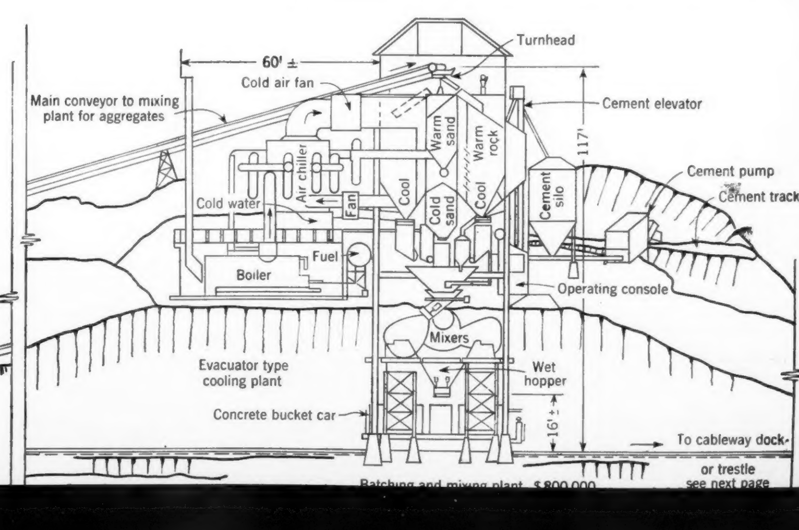


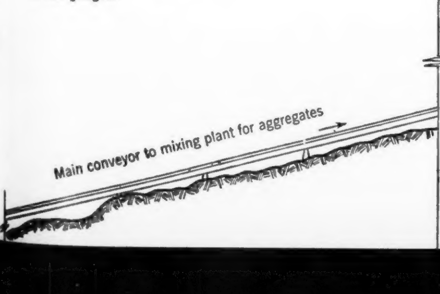
FIG. 11. **Dumpcrete trucks, employed for transporting dry-batched, plant-mixed concrete to large projects, cost about $4,000 plus truck chassis.**

CONCRETE PLANT FOR A LARGE DAM



For a large dam, this plant layout and flow line for making and transporting aggregate, and for cooling, mixing and placing concrete, can deliver concrete at a design rate of 240 cu yd per hour. Two accepted methods of placing the concrete in the forms appear on the next page.





Selection of primary crushing equipment is dependent on the sizes of rock obtainable from the quarry chosen, with the least amount of drilling and the smallest expenditure of explosives.

The flow line shown in Fig. 12 is typical for the production of aggregate from a massive micaceous granite—the final maximum size of rock to be 6 in. Selection of a No. 48 primary crusher, capable of taking 48-in. rock, was dictated by the size of rock economically obtainable from the quarry. A crusher of the gyratory type, instead of the jaw type, gives better tonnage per hour, produces rock pieces of the desired cubical shape, and turns out a greater quantity of the coarse and fine aggregates required. The auxiliary primary gyratory crusher (No. 22) was selected to reduce to 6-in. size that part of the product of the No. 48 primary crusher which is larger than that size. Screen sizes were selected to handle the design tonnage with a large factor of safety for economy.

The raw, crushed, stockpiled material can be transported by an aerial ropeway, as shown in Fig. 12, or by belt conveyor, railroad, or roads and trucks. Final selection of one of these methods depends on a detailed analysis of the terrain, market conditions, and the contractor's preferences.

Location of the secondary crushing, washing, screening, and sand-making installations was chosen to reduce water costs, the quarry being 1,200 ft higher than the river and the secondary plant near river level. The secondary plant is of first importance, and by far the most costly part of the aggregate-making setup.

Sand making is a specialized art. The plant illustrated in Fig. 12 employs wet screens, crushers, rod mills, sand dewaterers, and particle-size separating equipment. The relationship of these to each other is an engineering problem requiring specialized knowledge based on experience.

Because of the chemical reactions of setting, large masses of concrete generate considerable heat, which must be dissipated to prevent shrinkage and contraction cracks in the concrete. A recent development for cooling aggregates is shown in Fig. 12. This is known as the Hightower Croll Reynolds process and involves the use of vacuum chillers and spaces. This method is a great advance as it reduces the cost of keeping concrete temperatures down to levels required by present-day specifications.

Older and tried methods include inundating the aggregates in cold water, circulating refrigerated air through them and circulating cold water through pipes laid in the concrete.

Equipment for the mixing plant and for cement handling is on the market and readily obtainable. In the concrete mixing plants of Fig. 12, four 4-cu yd mixers are shown; these together have a maximum capacity of 320 cu yd of concrete per hour. The design average output of the cooling and mixing plant will be about 240 cu yd per hour.

Two general methods are in use for getting the concrete from the mixing plant into the forms—by cableways or by cranes running either on the ground or on trestles. The haulage system consists of cars on rails, ordinary trucks, Dumpcrete trucks, or transit-agitator mixers supplying either cableways or cranes. A cableway with a capacity of 8 cu yd per trip is shown in Fig 13. Three of these are required to utilize the full capacity of the cooling and mixing plant shown in Fig. 12. An alternative plan (Fig. 14) utilizes three or four gantry whirley cranes capable of placing the same amount of concrete per hour from a steel trestle.

The final choice of one or the other of these methods depends on the length and height of the structure to be built; the contractor's equipment inventory; and the size and training of his forces. Generally speaking, the crane method will be chosen for a long, low structure, and the cableway method for a short high dam.

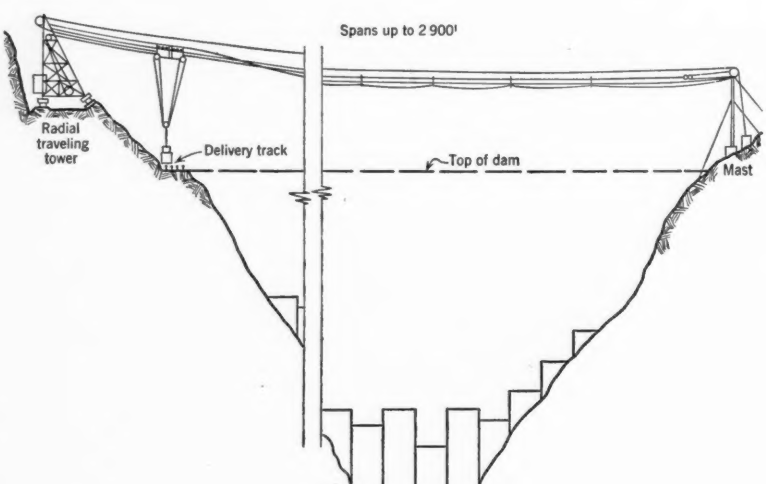


FIG. 13. Placing concrete in short, high dams calls for overhead cableway equipment.

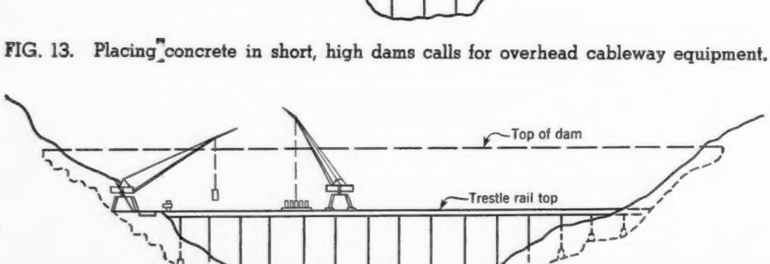


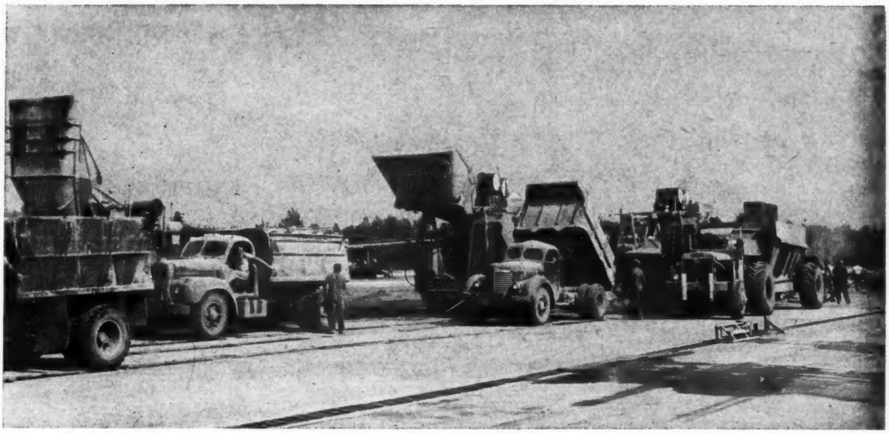
FIG. 14. For long, low concrete dams, trestle and gantry cranes usually are chosen.

Adequate maintenance shops needed

Repair and maintenance shops and shop practices are as vital to the successful use of these tools as is the choice of the tools themselves. Machine tools; tire shops; a carpenter shop; rigger, pipe, structural, and sheet-metal shops; oxygen and acetylene equipment; grease trucks; fuel trucks; pickups and jeeps—all of these, plus a myriad of service machines, are essential facilities for the successful contractor who uses modern methods and machines in construction. Shop costs can amount to as much as 10 percent of the cost of the job.

In sum then, the utilization of modern tools is a function of management; the selection of tools for specific uses is an art; the maintenance of modern tools is a science.

In the preparation of this article, the help of the author's associate, Frank O. Grubel, equipment engineer, is gratefully acknowledged.



Continuous stream of trucks dump aggregate into three concrete pavers placing one 24-ft strip of concrete at Plattsburg, N.Y., Air Force Base. Job is organized to get maximum production by extensive use of large pieces of equipment.

The modern highway construction plant is geared for production

D. W. WINKELMAN, M. ASCE, President, D. W. Winkelman Co. Inc., Syracuse, N. Y.

If I were asked what single factor is the keynote to modern highway construction, I would have to answer, production. The combined talents of highway constructors, their big machines, their construction plants, and their operating staffs are all organized so as to move the most earth and rock, place the most concrete, or erect the most steel at the lowest possible unit cost.

A contractor transplanted suddenly from a 1930 to a 1955 road-building job site would have difficulty recognizing what was going on. The huge trucks rumbling along at a good clip, dropping 15 or 20 cu yd of fill at a time, or the mammoth scrapers scooping up 12 and 13 cu yd of borrow in one pass and spreading it as quickly, would bear no similarity to the operations of a quarter century ago. The long line of specialized equipment—the subgrade planers, tampers, pavers, spreaders, screeds—shuffling forward leaving a ribbon of finished pavement behind would be a revelation. On the newly placed concrete, piles of damp straw are nowhere in sight. Instead, a rig with a spray bar spreads a chemical curing compound.

And what does a setup like this put out in one shift? Under favorable conditions there should be from 1,800 to 2,000 lin ft of new 12-ft pavement at the end of an 8-hour period. There is other equipment on the job site too—trucks feeding aggregate to the pavers, batching plants carefully weighing the components of the mix to assure full control over quality of concrete. The visitor from the past would not find many mules, hand shovels, or pickaxes.

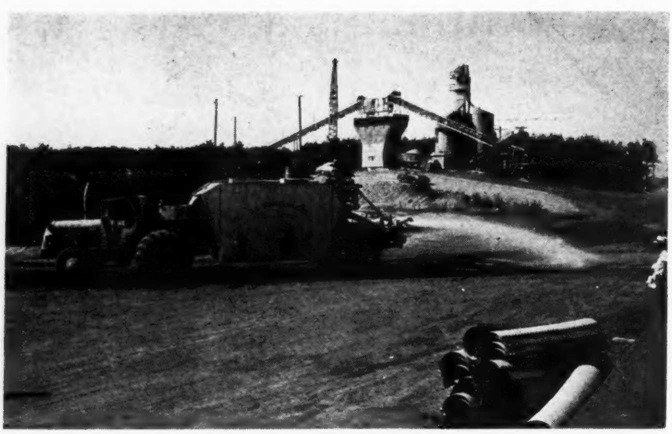
All this mechanization does not reflect a small boy's fascination for machines on the part of the contractor. It means only one thing to the hard-headed hard-hat—production.

This advanced degree of mechanization has not only served to offset the mounting costs of labor and equipment but has in fact made feasible the tremendous road-building programs of the present day. For example, L. J. Missimer, Director of the Virginia Road Builders Association, in an article in the March-April issue of *The Virginia Roadbuilder*, has calculated the manpower and animal power needed to perform a good-sized 1955 grading job with 1922 methods, to get the same production we can expect today. The assumed job involves 500,000 cu yd of excavation, with an average haul of 1,500 ft, 15 percent rock, and 50,000 tons of stone surfacing. The production schedule calls for 4,000 cu yd per day and 1,000 tons of stone surfacing per day. The requirements would be about as follows:

Mules	7,800
Men	7,200
Scrapers	1,000
Ploughs	35
Steam engines and rollers	70
Rock crushers	20
Carts and wagons	1,000
Hard-wheel power shovels	20

Aside from the tumultuous impact that 7,800 mules and 7,200 men would have on any community, it would take a right-of-way 100 ft wide and 5 miles long just to hold the men and equipment, with little room left to work in.

Conveyor system can handle four types of aggregate at one time and provide close mechanical control over batching of aggregates.



Besides controlling dust, home-made sprinkler carefully controls moisture of subgrade for compaction.

Not all machines on job are big ones. Specialized functions may require small rigs, such as Caterpillar scraper in foreground, for moving limited quantities of earth, and Austin-Western hoist in background, for placing and removing metal side forms.

Obviously, without the highly mechanized, highly productive contracting organizations we have today, there would be no turnpikes or superhighways of the sort demanded by modern traffic.

The real secret of adequate planning is not merely the application of many big and specialized machines. There are a number of machines of various types and sizes that will move earth or rock from one place to another. For that matter, there are several machines that could be used on almost any road building operation. The problem is primarily one of choosing the proper combination of machines so that the greatest amount of material can be moved in a given period. Many factors influence this choice, including such obvious considerations as type of material being hauled, length of haul, and type of terrain over which the hauling equipment must move. Also to be considered is the type of excavation. Is it rocky or soft? Is it from a high vertical face or from a pit? Other factors are availability of skilled labor, equipment already on hand, availability of new equipment, parts supply and simplification of parts inventory.

Choice of plant

Choice of plant and method of operation it can be seen is a complex problem. A series of papers presented before the Construction Division at ASCE's 1954 Annual Convention, and printed in Civil Engineering (December 1954 and January, February, March 1955), gives an excellent picture of the steps to be followed in choosing the right machine for the job. I will not attempt here to explore the intricacies of this problem.

A contract awarded to my firm for a section of the Ohio Turnpike is a good example of how such a problem is attacked. We decided the volume of concrete (about 125,000 cu yd) was such that a central-mix plant and non-agitating haul would result in high production, lowered maintenance, fewer breakdowns, more rigid control of the concrete, and flexibility of operation. Our plant was fully automatic, and a selector knob enabled us to change the mix instantly. Thus we were able to produce and pour two classes of bridge concrete and pavement slab all in the day's run, without delay in changing the mix. Further, it was felt that after the method had been applied on two or three jobs, savings in cost would result.

Obviously if the economies inherent in highly mechanized operations are to be realized, it is necessary to plan in large quantities. The capital investment in construction plant must be

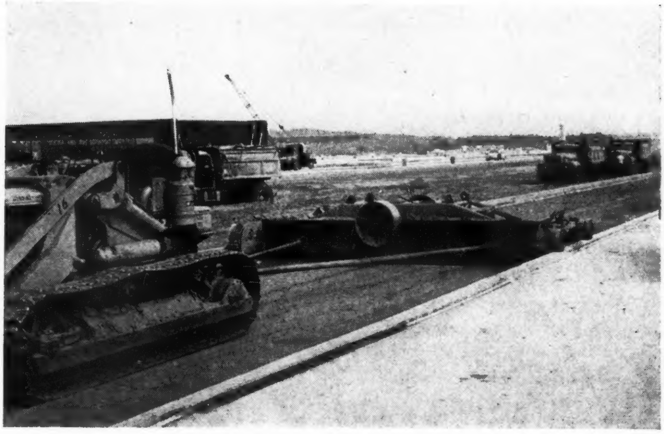
written off against large-scale operations if the unit costs are to be competitive. This then is the principle characteristic of modern highway construction—large scale.

Cutting down delays

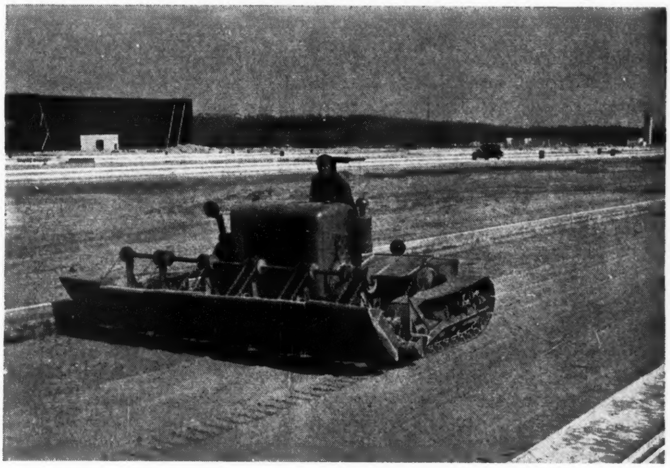
Once the plant has been organized and the equipment chosen, it does not mean that the problems of production are solved. Quite the contrary. Since the operation is predicated on many repetitions of each element of the job, small factors take on great significance. Assuming that the plan of procedure affords the optimum production for the given job conditions, the problem of production resolves itself into one of keeping each piece of equipment producing at maximum rate and eliminating all delays as far as possible.

Students of the art of construction planning divide delays into two categories—long delays and short delays. The dividing line is generally taken at about 15 minutes. Long delays are those involving down time for periodic maintenance, repair time for breakdowns, and similar instances when the equipment is out of action. Short delays are those resulting from inefficient operations, such as a shovel waiting for a truck to fill, or conversely trucks waiting in line at the shovel to be filled, or pusher-loaded scrapers waiting for a dozer to complete their loading. Of the two, short delays are the more costly since they occur when job overhead is at a maximum, when full crews are on the job and the many integrated operations, fully interdependent, are under way. It has been estimated by the U.S. Bureau of Public Roads that 16 minutes of productive time out of each hour is lost in short delays, on the average, for all road building equipment. The figure varies from contractor to contractor and is generally conceded to be the factor that separates the successful from the unsuccessful contractor.

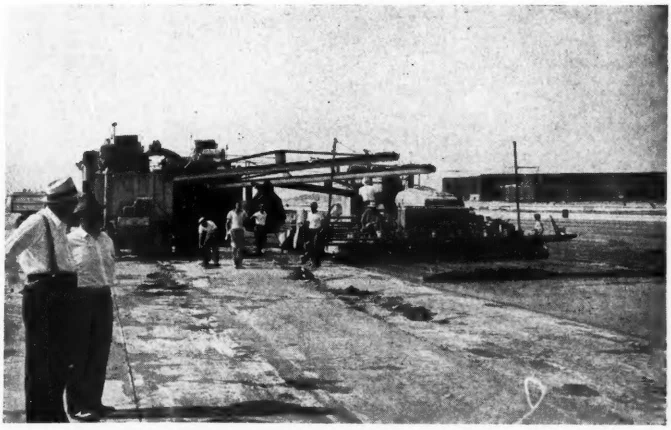
I do not mean, however, to minimize the effect of long delays on the productivity of a well organized job. Parts replacement and repair, if not carefully controlled, can grow to significant proportions in a mechanical complex such as that outlined above. The fleets of trucks, excavators, pavers, and finishers are only the front line of the equipment to be found on the modern highway construction job. Behind these is another complete organization for repair, which includes maintenance machines and gear. While not actually engaged in the productive work for which the contractor is being paid, this echelon of operations is as important to the basic objective of maximum

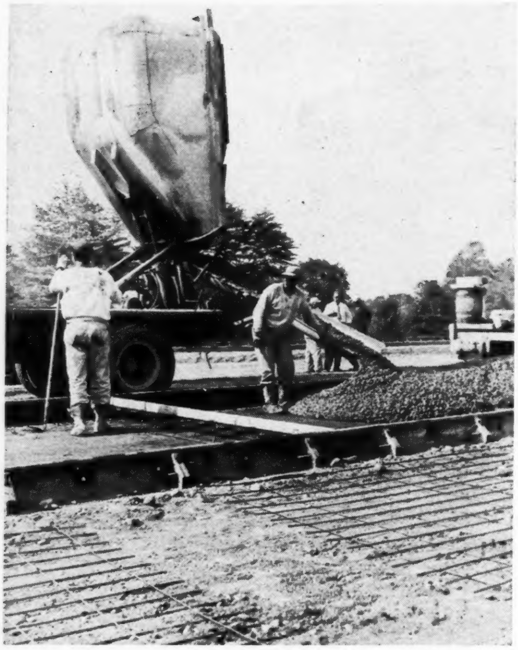


Close control of subgrade elevation can save contractor many headaches and excessive costs. Thus investment in subgrade planer, above, and tamper, below, is well justified.



Three pavers feed one spreading and finishing outfit. Setup such as this requires extensive maintenance facilities, which are characteristic of modern construction.





Need for high production rate led to choice of central mix and non-agitating haul for section of Ohio Turnpike pavement. Speed and volume of materials to be handled dictate size and type of equipment chosen by the modern contractor.

production at lowest cost as any single phase of the operation.

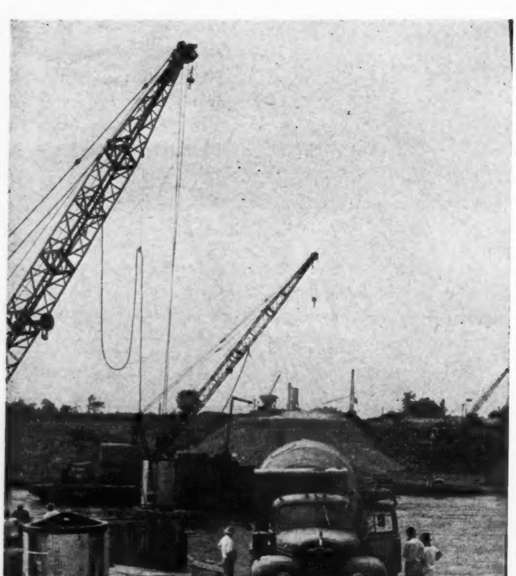
As an example of the magnitude of this phase of the contractor's organization, let us consider a large paving operation at Plattsburg, N. Y. Here an area of about one quarter of a square mile is being paved to a depth of 14 in. The quantity of concrete being placed is about 400,000 cu yd. The quantity of earth moved is about 3,500,000 cu yd. Placement of concrete is at the average rate of about 3,500 cu yd per day.

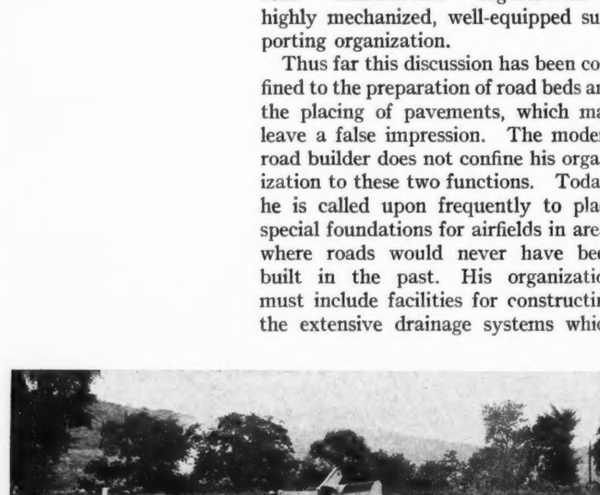
The principal equipment for grading, placing of concrete pavement, excavating and batching of aggregates is as follows: 15 rubber-tired scrapers, 4 pavers, 2 complete spreading and finishing outfits, and one batch plant. This is exclusive of the many small items of equipment and the hand tools necessary on any construction job.

To operate this equipment there are about 300 men on the job. They are organized into two 10-hour shifts, with the four remaining hours of the day devoted to maintenance of equipment. To support this operation on the established schedule requires a complete maintenance organization with a fully equipped shop, a yard crane, welders, grease rigs, and a stock of spare parts.

It can be clearly seen from this that the capital investment for maintaining a construction plant is a significant item. Here then is another characteristic of a mass-producing, modern, road construction organization—a highly mechanized, well-equipped supporting organization.

Thus far this discussion has been confined to the preparation of road beds and the placing of pavements, which may leave a false impression. The modern road builder does not confine his organization to these two functions. Today, he is called upon frequently to place special foundations for airfields in areas where roads would never have been built in the past. His organization must include facilities for constructing the extensive drainage systems which





To answer specific needs of the contractor, new items of equipment are constantly being introduced, such as hydraulically operated, sealed Gar-bro bucket for tremie pours (above) and 34-cu yd Wooldridge scraper (right).

are an essential part of modern high-speed highways. He must also be equipped to construct the many grade separations and bridges which are essential to the modern pattern of uninterrupted, safer traffic flow. Each of these engineering features requires its own specialized line of equipment although mechanization has not been carried to the same degree as on the road itself. Paving and grading operations have been chosen for discussion merely as examples of modern road-building operations.

It is not to be implied that these varied operations are not integrated equipment-wise within the construction schedule. As one phase of the work is completed, equipment is shifted to other activities. A crane with clamshell attachment does not sit idle while waiting for another foundation to dig when there are forms that can be placed and steel that can be erected.

Another phase of modern road building that must be mentioned is the extremely important and complex problem of manpower. Since 1937 there has been a great increase in the multiplicity of trade union organization. Today one man is rarely permitted to perform more than one function on most construction jobs, and therefore the organization of manpower on a job has become more complex than the organization of machines. Jurisdiction of jobs has become one of the most puzzling problems of the industry. On our Ohio Turnpike work, we were dealing with six separate trade unions. On the New York Thruway we had to operate through seven trade unions.

Engineer-contractor relations

Another facet of road building that has a direct bearing on the productive efficiency of the contractor (and ultimately on the cost to the using public) is the relationship between the constructor and the designer or owner's engineer. It is an intimate relationship that should be based on mutual trust and respect for the professional judgment and experience of both parties. Only by a complete integration of the contractor's knowledge of his machines and what they will and will not do, and the engineer's knowledge of the materials of construction, their capacities and limitations, can the ultimate in construction efficiency be achieved.

The engineer controls the quality of his structure in two ways—by the specifications he writes into the contract and by the inspection he maintains during construction. That these two factors have a significant effect on the productivity of the contractor's organization is obvious. Specifications that are insufficiently definitive handicap the contractor in planning his job organization and may lead to the selection of equipment that is not the most productive for the job conditions. Inadequate specifications also frequently lead to higher bid prices. On the other hand, specifications may be so restrictive that the contractor's ingenuity is restricted and full advantage cannot be taken of his experience. In either case it is the highway user who ultimately pays.

As has been noted, inspection is the other means by which the engineer controls the project. It is unfortunate that job inspection is one of the earlier tasks in the career of the young engineer. With only moderate experience, the young inspector frequently is not qualified to make on-the-spot decisions, and the time lost in seeking out the qualified authority is paid for in lost production. The fault lies not with the young engineers, who are not given great latitude in the exercise of their judgment, nor for that matter with the highway departments that put these men on the job. It lies rather with those who, in their ignorance of road building and procedures, allocate inadequate funds for this phase of the work. It is false economy. Money saved in inspection costs is lost many times over in construction cost.

There are other ways in which the engineer can ensure maximum economy to his client. By standardizing structural features, the designer gives the constructor the opportunity to use his big machines to the best advantage. For example, it is frequently cheaper to excavate more than is absolutely required for a structure where by so doing production can be kept at a maximum and hand labor can be cut down. The large canal-lining machines used in the West on irrigation projects are operated on this principal. Repetitive designs such as those for the long vehicular trestles across Hampton Roads and Lake Pontchartrain are another example of the designer's role in furthering economical construction procedures. In both these cases, the contractor can organize an extensive fabrication yard to turn out identical units at a high production rate and low unit cost.

Designer needs knowledge of equipment

It is clear then that large scale is an essential if a wide variety of huge, special-function machines are to be used effectively. Evidently it is advantageous to divide a major highway project into large enough contracts so that the contractor can make effective use of a highly mechanized organization. The same result may be achieved by the contractor who successfully bids on several adjacent sections of a turnpike, but the uncertainty under this procedure may force certain compromises in his basic plan of operation.

It has further been found advantageous to include all items for one section of a turnpike in one contract. In this way, no time is lost by one contractor who has to wait for another to get out of his way. It saves on moving equipment from job to job, and generally results in more efficient use of equipment on the particular contract. This type of contract not only contributes to greater productivity of equipment but ultimately results in lower costs to the state or road authority.

My last point is that the designer of a structure should have full knowledge of the machinery available to build it, and his decisions regarding the basic components of the structure should be leavened by the "how-to" of the project as well as by the "what."

Do not draw the conclusion from these remarks that I advocate the status quo in road building and that progress and new ideas are to be eschewed by the designer. Quite the contrary. It is the challenge of new problems that exhilarates the man who loves construction as I do. We have not yet reached the ultimate in the design and construction of roads. Twenty-five years from now the highway construction site may seem as strange to us as today's site would seem to our hypothetical visitor from 25 years ago. Subgrade planers may then be as antiquated as the mule and Mormon board. However, unless we fully understand the principles of optimum production in road building such progress will not be realized.

Construction is an industry that comes closer to the concept of free enterprise than any other in this nation. I believe that it is competition which has fostered this progress in construction techniques unequaled anywhere else in the world. Construction by contract has spurred the ingenuity of constructors and has made efficiency a necessity. This method of doing business has been as significant to progress as the machines we have developed.

The production of safe, pleasant, economical highways can result only through teamwork in thinking between the man who conceives the structure and the man who builds it. The construction industry has never been slow in developing new machines to take advantage of new design techniques arising from our ever-increasing knowledge of the materials of construction. But it should never be forgotten that for ultimate productive efficiency, design must keep abreast of the continually increasing stock of road-building machines.

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BIG EQUIPMENT *sets the pace in race for more*

A characteristic of our civilization is an apparently insatiable demand for power, and the relatively young science and art of hydroelectric engineering has contributed its share towards meeting this demand. Progress has been made in several directions, including: (1) increase in total capacity, (2) spread of geographical coverage, (3) coordination with other forms of power, and (4) improvements in technical features.

Our power era or industrial revolution may be dated roughly from the beginning of the nineteenth century. Although water power has been a popular form of power from very early times, the hydroelectric science and art date roughly from the beginning of the present century, by which time high-voltage transmission was coming to be well established. Although steam power had a one-hundred-year head start on hydroelectric power, for present purposes we can trace the modern phase of development of each from the start of the present century, because it was electric transmission and distribution that really brought power to everyone for the first time.

Increase in total capacity

According to U.S. Geological Survey publications, the world total of installed capacity of water-power plants increased from 33 million horsepower in 1926 to 115.7 million in 1952. (These data are the nearest available for the 1930-1955 period being celebrated in this anniversary issue. The article, however, is not confined exclusively to this period.) The United States percentages of those totals were respectively 34 and 27 percent.

Table I shows the division of world power, both hydroelectric and total, between continents, with an indication of the installed horsepower per capita. This table gives a useful overall picture of the place of hydroelectric power in the world power economy. It would be interesting,

TABLE I. World power by continents in 1952*

Continental or Oceanic Area	Hydro hp (Millions)	Total hp (Millions)	% Hydro	Population‡ (Millions)	Total hp Per Person	Potential Hydro hp § (Millions)
Africa	0.7	7.1	10	190	0.04	250
Asia	14.4†	25.7	56	1,210	0.02	156
Europe	48.5	163.0	30	600	0.27	64
North America	46.4	151.0	31	220	0.69	90
Oceania	1.8	6.1	29	130	0.05	23
South America	3.9	8.6	45	120	0.07	62
	115.7	361.5	32	2,470	0.15	645

* Information in this table is from U.S. Geological Survey Circular No. 329, Washington, D.C., 1954.

† Approximately two-thirds of the hydro capacity in Asia is in Japan, with about 7 percent of the population.

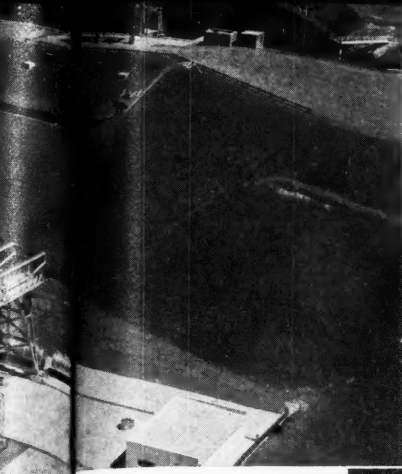
‡ The population figures have been rounded off.

§ Based on ordinary minimum flow and 100 percent efficiency.

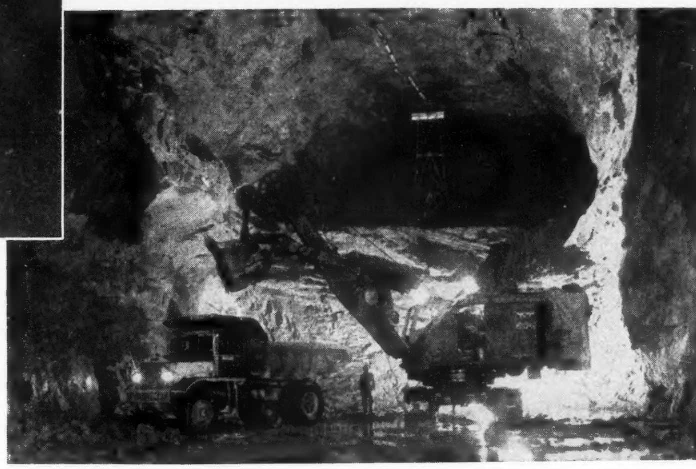
TABLE II. Annual electricity consumption as of 1952*

Country	Kwhr Per Year Per Capita	% Hydro Capacity
Norway	5,750	95.8
Canada	4,830	90.4
Sweden	3,140	77.3
Switzerland	2,790	93.8
New Zealand	1,830	88.5
United States	3,220	22.2

* Data taken from 1953 mimeograph release of Federal Power Commission.



Advent of outdoor and underground power stations has reduced cost and time of construction of hydro plants. Photo at left shows outdoor-type C. J. Strike Hydroelectric Development of Idaho Power Co. Under construction in photo below is underground Harspranget Power Plant in Sweden.



power

but beyond the limitations of this article, to break down the figures for individual countries. However, Table II gives, as of 1952, the annual per capita consumption of energy in five countries where production is overwhelmingly hydroelectric, as compared with that in the United States.

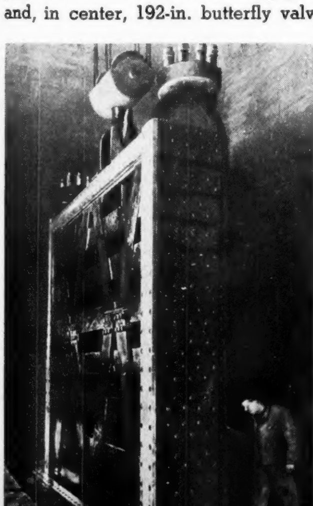
A very noticeable feature of the development of hydroelectric power during the past 25 years has been the relatively great increase in countries which previously had little or none. Sizable installations have been or are being made in such countries as Afghanistan, Egypt, Greece, Iceland, Israel, Labrador, Syria and Uganda, while outstanding developments have continued in countries such as Australia, Austria, Belgian Congo, Portugal, Scotland and Spain, which previously had relatively modest amounts. The countries that pioneered in hydroelectric development—such as Canada, France, Italy, Norway, Sweden, Switzerland, and the United States—have continued to make notable strides.

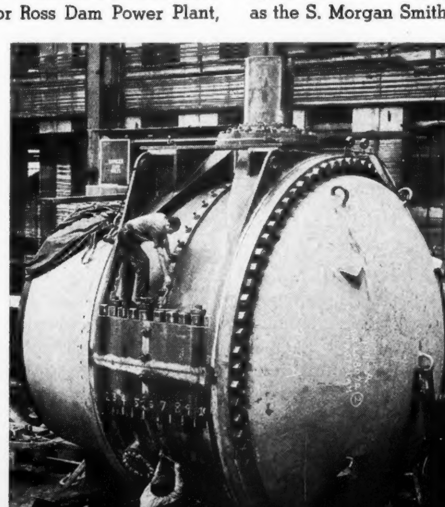
Value of coordination

For many years hydroelectric power was regarded strictly as a competitive form of power to be compared economically with thermal power, but the tendency in recent years has been to recognize that it serves a function which thermal power either cannot serve or cannot serve nearly as well. Hydro acts as a flywheel to the system, leveling out peaks, and is able at a moment's notice to supply sudden surges in demand. It has come to be recognized that in many cases the addition to a system of a certain proportion of hydroelectric capacity may have a value far transcending the net capacity added. Conversely the addition to a predominantly hydro system of a certain proportion of thermal capacity may have real value in firming up energy which otherwise is of little value.

Coordination of systems, comprising thermal power, run-of-river and

Ruggedness marks trend in gates and valves, as can be seen in photos below. At left is sliding gate for Genissiat Dam in France and, in center, 192-in. butterfly valve for Ross Dam Power Plant, Seattle, which operates under 520-ft head. For higher heads, spherical and conical type valves are finding wide acceptance, such as the S. Morgan Smith 84-in. roto-valve shown at right.





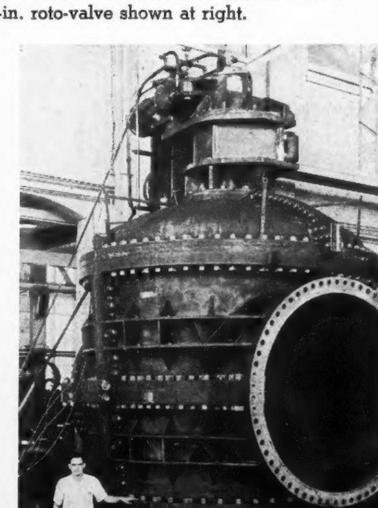


TABLE III. Water hp of large pressure conduits*

Year	Plant and Location	Head, ft	Dia., ft	Discharge per Conduit, cps	Power per Conduit, hp
1942	Innertkirchen, Switzerland	2,200	8.5,7.9	1,410	325,000
1954	Montpezat, France	2,080	8.5	779	162,000
1954	Kemano, B.C., Canada	2,597	11	6,920	560,000
Projected	Roseland, France	3,840	9.8	1,770	660,000

* This table is adapted from Tables 5 and 6 of "Present Trends in the Design of Pressure Tunnels and Shafts for Underground Hydroelectric Stations," by Dr. Charles Jaeger, Paper No. 5978, Inst. C.E., 1954.

TABLE IV. Comparison of penstock weights under different design and construction techniques

Case	Approx. Date	Type of Construction	Total Weight of Steel, metric tons
1	1906	Riveted	28,930
2	1910	Gas welded	9,500
3	1936	Arc welded	3,220
4	1951	Prestressed and artificially aged	2,000
5	1951	Banded, prestressed and artificially aged	1,455

storage hydro power, has been intensively studied during the past fifteen or twenty years and has in some instances reached a high degree of perfection. It has been stated that perfecting the operation of the Pacific Northwest Power Pool in effect added 700,000 kw to the effective output of the associated systems. Other instances of effective coordination between systems are numerous. One notable example is the power system of the Italian peninsula, where different characteristics of the Alpine and Apennine plants are coordinated by means of the backbone tie, and where, since the war, the use of seasonal pumped storage has become a valuable feature in coordinating not only the hydro capacity but the thermal and geothermal capacity of the whole country.

Technical improvements

Hydroelectric development in general comprises many features. Improvements in all of them should be given some recognition in any study such as this, by giving a few notable examples.

Dams. The gravity dam continues to be the work horse for storing water, and advances in it have been in size rather than in new developments. In many countries notable advances have been made in the massive buttress dam, which probably will play an increasingly important part in the art of dam building in cases where only gravity dams would have been considered previously. The arch dam has been the vehicle of many bold advances, including increase of crest length (Hungry Horse, 2,130 ft), successive increases in height (Ross Dam, from 220 to 675 ft in four stages), use of peripheral jointing (Pieve di Cadore and many others), unprecedented height (Mauvoisin, Switzerland, 745 ft), each in its way tending towards a more scientific use of the concrete to carry the load. The arch dam has also won recognition in Japan, where previously the very substantial hydroelectric economy had been built up on the basis of the gravity dam. The rock-fill dam has undergone some notable advances, especially the impervious-core type. Earth dams have continued to increase in size and in scientific management of the materials employed, and have reflected the veritable revolution which has taken place in earth moving in the past 25 years.

Gates. Accessories of dams have been greatly improved, thus contributing in no small measure to the reliability of power plants. Spillway gates have been increased in size, and emphasis has been placed primarily on reliable operation and minimum maintenance rather than ingenuity in design. Intake gates have, in some cases, become of very large size. At McNary the expedient was adopted of operating the 20-ft-wide by 51-ft-high gates by means of hydraulic cylinders forming an integral part of them, so that the whole assembly of gate and operating mechanism could be lifted as a unit by the gantry crane.

Free discharge gates and valves have been greatly improved in the past 25 years and do not now present the problems they once did. Both roller and slide gates of large size and for high heads have been used with satisfactory results. Butterfly valves and valves of the needle type, which have been used for many years, have been rendered more reliable and sturdy. For higher heads they have been largely replaced by valves of the spherical or conical type, of which several variations are available, offering a smooth passage when open.

Pressure conduits. Progress in pressure conduits has been enormous. The tendency towards the use of pressure tunnels has grown, especially in Europe, and the division of stress between rock and steel lining (if any) has come to be better understood as a result of scientific studies, and some unfortunate experiences. Table III lists a few of the important pressure conduits of large size.

Great advances have been made in the use of special steels and higher stresses in steel penstocks, and the difficulty in fabricating penstocks of large diameter and thickness combined has been met to a considerable extent by the use of the banded or prestressed cable-wrapped pipe. A leading French firm which has pioneered many developments in high-head penstocks made a comparison of a certain penstock assemblage, assuming it had been designed and built at different periods, using the best materials and technique current at the time, and in each case designed for the same loss of head and for a waterhammer pressure appropriate to the arrangement of the penstock. The tabulation, Table IV, shows better than many words what enormous progress has been made.

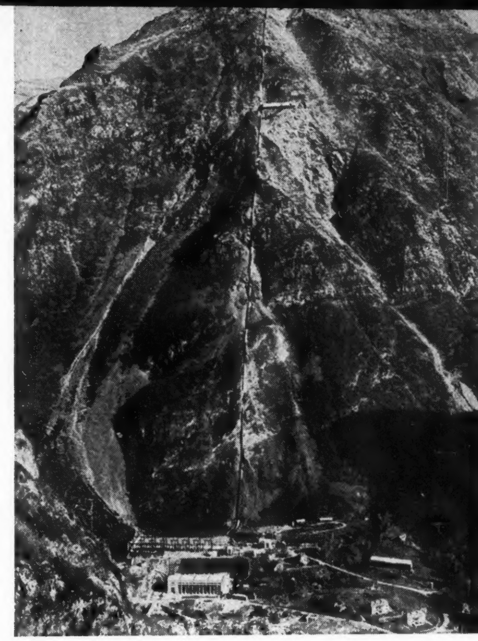
Types of plant. Two advances in power-station design that have occurred almost entirely within the past 25 years are the use of outdoor stations and the use of underground stations. The outdoor power plant

TABLE V. Notable underground plants*

Date	Plant	Capacity, kw	Gross Head, ft	Turbines	Powerhouse Volume per kw Installed, cu yd
1942	Innertkirchen, Switzerland	210,000	2,200	5 vert. Pelton	0.28
1951	Harspranget, Sweden	288,000†	353	3 vert. Francis	0.22
1954	Montpezat, France	116,000	2,080	2 double-overhang Pelton	0.226
1954	Kemano, B.C., Canada	835,000†	2,597	8 vert. Pelton	0.347

* Adapted from Dr. Jaeger's Table 7 (op. cit.).

† First stage.

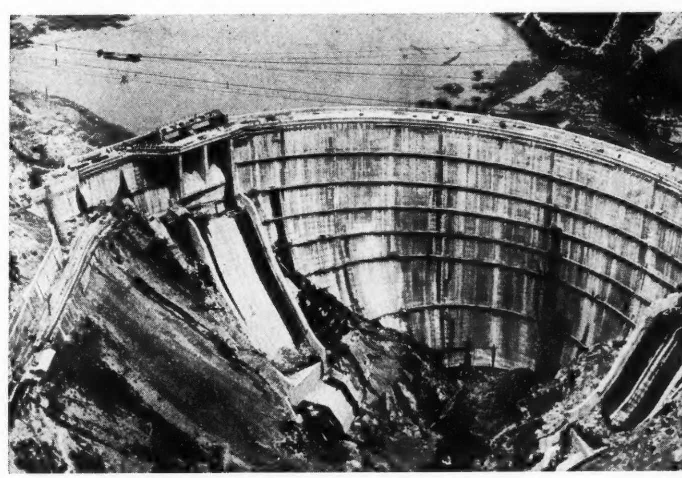


Fabrication of steel penstocks has made great progress. The introduction of prestressed banded pipe has made it possible to build penstocks such as Cap de Long for Pragneres Powerhouse, with a head of 4,080 ft and capable of developing 205,000 hp.

has been found equally as reliable and convenient in operation as the more conventional fully housed plant, and has reduced the cost and time of construction very considerably, thus placing hydro power in a better competitive position. The underground plant has the main advantage of giving the designer much more freedom in locating the conduits and the plant itself in space, without being slavishly bound to surface contours, and this may in many cases result in great savings in pressure conduits, and in an increase in overall efficiency due to the reduced length of such conduits. Plants of very large size have been built underground, and a few outstanding ones are noted in Table V.

Another innovation within relatively recent years is the extreme simplification of power-plant arrangement aimed at in the straight-through turbine-generator, which has been devised for the economical development of relatively small amounts of power at low head. In such cases, conventional plants would be relatively expensive. This type of plant is still in the experimental stage, but shows promise of wider use. See Fig. 1.

Equipment. Turning now to equipment, the two principal elements are



Arch dams are winning increasingly important place in hydro-power economy of Japan. Kamishiiba Arch Dam, with height of 366 ft, is typical of this trend.

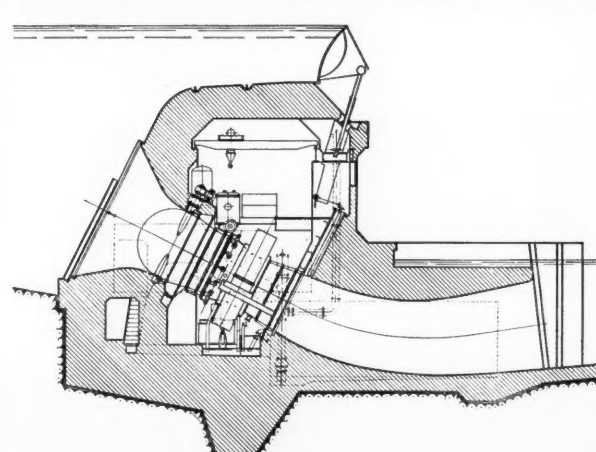
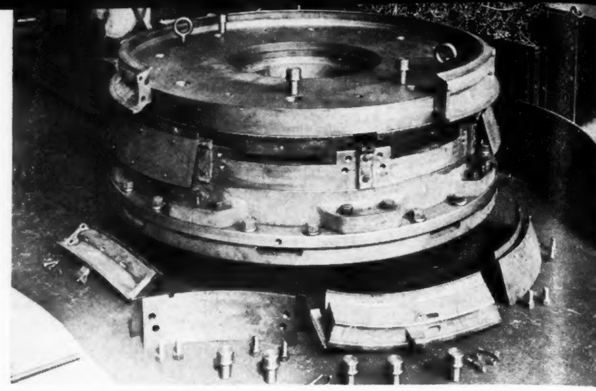
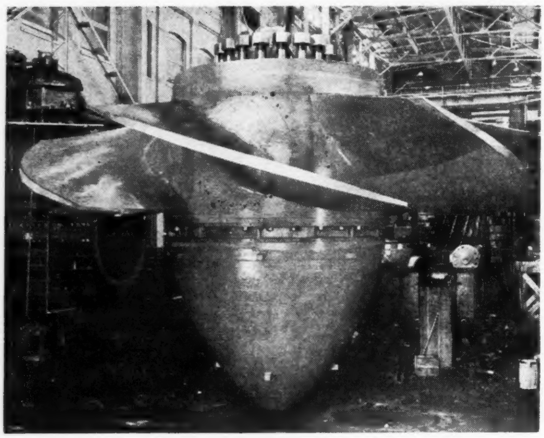


FIG. 1. Development of the straight-through turbine-generator such as that installed at Saalach, Austria, promises great economies for generation of relatively small amounts of power at low head.

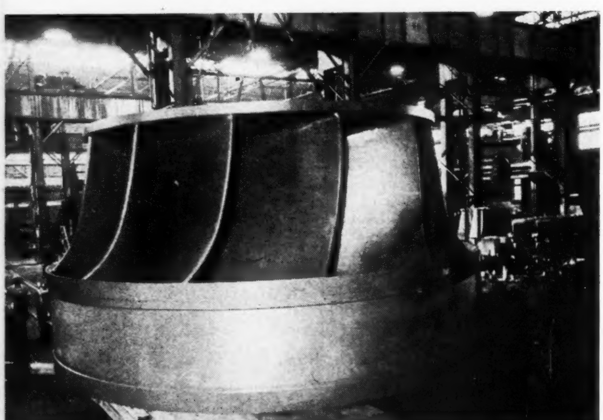


Greatest advance in hydro equipment development was probably pivoted-shoe thrust-bearing such as 85 1/2-in. Kingsbury equalizing thrust bearing at Hoover Dam Power Plant, which can take load of 1,800,000 lb with speed of 180 rpm.



Kaplan runner at McNary Power Plant

Largest one-piece Francis runner, at Garrison Dam Power Plant



Impulse runner for Reisseck Hydro Development, Austria

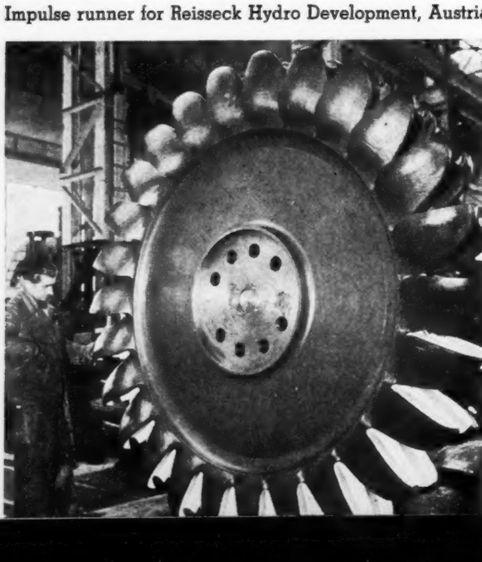


TABLE VI. Notable Kaplan runners

Name	Head, ft	Hp	Runner Dia.	No. of Blades	Weight of Runner, lb
Vargon, Sweden	14	18,000	26′ 3″	4	...
Pickwick, U.S.A.	43	48,000	26′ 4″	6	...
McNary, U.S.A.	80	111,300*	23′ 4″	6	423,000
Aswan, Egypt	102 max	65,000	18′ 5″	6	...
El Oviachic, Mexico	160	15,000	7′ 6″±	8	...

* Maximum output, 138,000 hp at 89-ft gross head.

TABLE VII. Notable Francis runners

Name	Head, ft	Hp	Throat Dia., in.	Remarks
Ft. Randall, U.S.A.	112	57,000	186	1 piece, 120,000 lb
Dnieprostroy, Russia	116.5	84,000	226.5	3 parts, each 82,000 lb
Garrison, U.S.A.	150	88,000	210.5	1 piece, 170,000 lb
Waneta, Canada	210	120,000		1 piece
Grand Coulee, U.S.A.	330	165,000*	172.75	1 piece, 125,000 lb
Bort, France	365	150,000	140	1 piece
Noxon Rapids, U.S.A.	152	137,500	222†	3 pieces

* Last 9 units.
† Tentative; final dimensions may be larger.

TABLE VIII. Notable Pelton wheels

Name	Head, ft	Hp	Speed, rpm	Remarks
Cimego, Italy	2,365	150,000	300	2 wheels, 1 jet per wheel
Avise III, Italy	3,400	78,000	500	2 wheels, 1 jet per wheel
Kemano, Canada	2,597	150,000	327	1 wheel, 4 jets
Reisseck, Austria	5,790	31,000	750	1 wheel, 1 jet

of course the turbine and the generator. It is probably safe to say that the greatest single advance in hydro-equipment development was the Kingsbury thrust bearing. It enabled units of increasing size to be constructed with vertical shafts and freed the designer almost entirely from the severe limitations of shaft bending moments. Efficiency was considerably increased by the more direct water passages, and also erection and maintenance were facilitated. Other types of thrust bearing were later developed and perfected, and it is now considered possible to make thrust bearings for almost any forseeable load. The largest to date are those at the McNary plant, running at 85.7 revolutions per minute and carrying a load of over 4 million pounds.

Gradually turbine makers availed themselves of the opportunities of increased size opened up by advances in thrust-bearing design as the generator manufacturers concurrently perfected their designs to enable the greater centrifugal forces to be successfully carried. The Kaplan runner was a key that unlocked the door to an enormous treasure house of low- and medium-head power. The European firm that first undertook the development of the Kaplan turbine has alone made over 550 wheels of this type with a combined power of nearly $2^1/_2$ million hp. A few Kaplan wheels which are notable in terms of horsepower, physical size, or high or low head are noted in Table VI.

The Francis runner, however, has exceeded the Kaplan type in horsepower, on account of the higher heads at which it can be used. See Table VII. The impulse wheel hardly yields pride of place to any other type as regards unit output, as Table VIII shows.

Increases in unit size, which have been characteristic of all power development, have made it virtually impossible to construct the largest spiral cases by riveting, and thus welded fabrication has come to play an important part. Welded fabrication has also been used in constructing many of the large parts of turbines of all types.

Governing equipment has kept pace with advances in the design and construction of turbines, and refinements have been introduced to enable a whole system to be adjusted so that each plant serves the purpose for which it is best fitted.

Pumped storage. Some noteworthy pumped-storage installations have been built and many others have been proposed. In general, pumped storage has been most effective for daily peaking, but several installations utilize seasonal storage—in Switzerland, Austria and Italy. For example, the Provvidenza storage plant in Italy has three power units, two of which include pumps absorbing 62,700 hp each, pumping against a head of 730 to 940 ft. See Fig. 2. These pumps have an average efficiency of approximately 90 percent. A further development in recent years has been the combined pump-turbine, which undoubtedly has a very bright future.

Generators. Progress in design and construction of generators has been astounding, and the manufacturers now claim that they can make a generator for any prime mover that the turbine people can produce. Complete enclosure, with forced-air cooling, is the general rule, and reliability has been brought to a high stage. New types of insulation have added greatly to reliability.

Transformers. Twenty-five years ago it was quite general practice to provide "spare" transformers, but this is seldom done now, such is the almost perfect record of the modern transformer. Sizes have been increased tremendously but transport limitations set a limit to what can be done. Oil-filled cables at voltages up to 220 kv have found increasing acceptance in Europe and elsewhere for relatively short underground runs.

Transmission. Circuit breakers and transmission lines have increased in capacity and reliability to keep pace with prime movers and generators. A transmission voltage of 380 kv has been achieved for the 600-mile line from Harspranget to Hallsberg in Sweden, and one 345-kv line is in use in the United States. Others are being considered. At least two 220-kv transmission lines now leap across the Alpine chain in the north of Italy at elevations of over 9,000 ft. The Straits of Messina have finally been spanned with a high-voltage transmission line. The 138-kv Paucartambo-Charhuamayo transmission line traverses the Andes in Peru at an elevation of 13,000 ft.

A constant striving for greater economy and efficiency will ensure that hydroelectric power fulfills its proper role in the atomic age which we are now entering.

Photos are used by courtesy of: Kamishiiba Dam, Kyushu Electric Power Co. and Ebasco Services Incorporated; Genissiat gate, Escher Wyss A. G. Zurich; Ross butterfly valve, Newport News Shipbuilding & Drydock Co.; rotovalve, S. Morgan Smith Co.; Cap de Long-Pragneres Penstock, Société Dauphinoise d'Etudes et de Montages; C. J. Strike Powerhouse, Idaho Power Co.; Harspranget Powerhouse, Swedish State Power Board; Boulder thrust bearing, Kingsbury Machine Works, Inc.; Kaplan runner, S. Morgan Smith Co.; Francis runner, Baldwin Lima Hamilton Co.; Riesseck impulse runner, Ateliers Charmilles, Geneva.

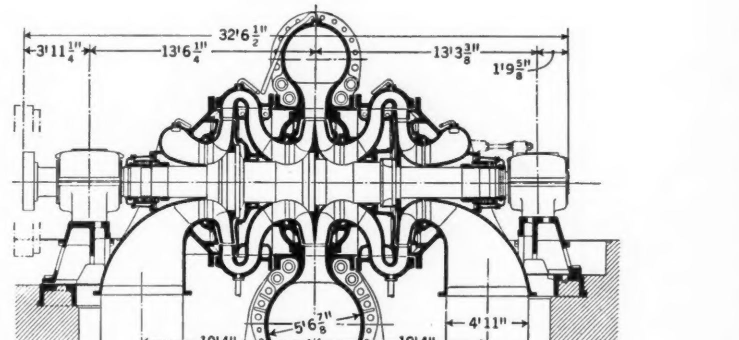


FIG. 2. Pumped storage is gaining acceptance in the hydro power field both for daily and seasonal peaking. Two-stage pump with double admission shown is for Provvidenza storage plant in Italy. Two of three power units at plant have pumps such as shown in Fig. 2, drawing 62,700 hp each and pumping against a head of 730 to 940 ft.

GEORGE G. MANOV

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Civil engineers play important part in constructing AEC plants. In view above, steel reinforcement is seen being installed in preparation for concrete pouring on atomic energy plant near Paducah, Ky. Preliminary sketch, to right above, shows nation's first central-station nuclear power plant, being built near Pittsburgh, Pa., as joint project of AEC and Duquesne Light Co. Left to right in this sketch appear: building to house fuel-handling equipment, atomic reactor and heat exchangers, maintenance building and overhead

Civil engineers needed in

This country owes a debt of considerable magnitude not only to the scientists who successfully split the atom, but to the engineers who took it out of the laboratory.

For instance, scientists knew that small atoms have an easier time wiggling through barriers than do larger ones, and this was one method by which possibly they hoped to separate the special Uranium-235 from the heavier, non-fissionable Uranium-238. This could be proved on paper and a laboratory scale. (There are also other processes capable of separating the U-235 from the U-238.) My colleague, Wilbur E. Kelley, former Chief of the AEC's New York Operations Office, has pointed out that the scientific principle of this process can be sketched on the back of an old envelope, but to translate this knowledge into practical use during the war took

450	buildings
32,000	tons of steel
15,000	construction people
$450,000,000	worth of effort
13,000	engineering drawings
6,000,000	cups of coffee, and innumerable gray hairs

Wide scope for civil engineers

The Atomic Energy Commission and its contractors employ a total of 7,077 engineers. A breakdown of their specializations would be as follows: civil, 491; chemical, 1,624; electrical, 141; mechanical, 1,804; metallurgical, 448; mining, 75; nuclear reactor, 355; unclassified, 867. Civil engineers therefore comprise about 7 percent of all the engineering personnel. The jobs that these men do for AEC and its contractors are along the lines of conventional, as well as "atomic-civil" engineering.

The Savannah River Plant is the largest single construction job ever undertaken by the Atomic Energy Commission. Its immensity is reflected in these facts:

1. The 126,000 carloads of materials required would, if placed in a single giant train, reach from Atlanta, Ga., to the Pennsylvania Station in New York.

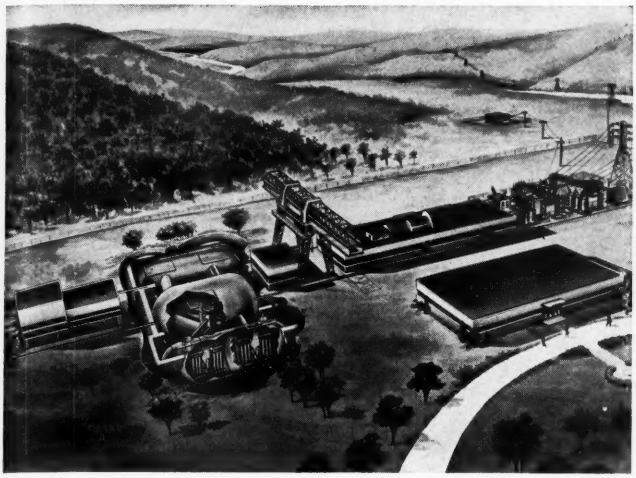
2. The 39,150,000 cu yd of dirt excavated is equivalent to a wall 10 ft high and 6 ft wide extending from Atlanta to Portland, Oreg., or approximately one-sixth of the 220,538,000 cu yd moved in digging the Panama Canal.

3. The 85 million board-ft of lumber required could build 15,385 houses, enough to house a town of 46,000 people (three to a house).

4. 1,452,482 cu yd of concrete has been poured. The 118,449 tons of reinforcing steel required is equivalent to 3,308 railroad carloads, or a train 30 miles long.

5. 159 miles of permanent new roads have been built, together with 82 miles of permanent new railroads in an area of 315 sq miles.

The Portsmouth, Ohio, plant required over 14,000 engineering drawings, enough to cover 2$^1/_2$ acres. Forty million gallons per day of water are required for plant operation and sanitary use. There are 595 miles of pipe of all sizes; 1,065 miles of copper tubing; 25,000 tons of reinforcing steel; 110,000 tons of structural steel; 590,000 ft of welding. The floor area of the Portsmouth process plants is about 25 percent greater than the area of the Pentagon, the world's largest office building. It took 145 million man-hours to com-



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traveling crane, turbo-generator building, switchyard, and (in right foreground) administration and shop building. In photo at far right, workmen assemble parts of concrete batching plant for use in construction of AEC's gaseous diffusion plant near Portsmouth, Ohio. Over 14,000 engineering drawings were required for this $1,219,000,000 plant, which will cover 25 percent greater area than the Pentagon.

© U.S. AEC

the atomic age

plete the project—enough to keep one man on a 40-hour week busy for 69,712 years. The peak total employment during construction was estimated at 22,500. The Paducah, Ky., plant is another large AEC construction project.

Three atomic towns have been laid out, starting from scratch. Among the requirements for one of these, Oak Ridge, was that the shopping center be built around two existing graveyards! In building this town as well as Los Alamos, N. Mex., civil engineers played an extremely important part in every step of the operations.

Here was an opportunity that many

© Genera lElectric Co.

With 3,850 tons of steel in place, hollow sphere which houses the atomic submarine engine at West Milton, N. Y., rises to height of 18-story building. From this type of plant "layout," useful information will be gained as to necessary size of exclusion area. Some way must be found to reduce large size of this area now required for atomic power plants.

engineers dream about, but in which few have a chance to participate. It is reminiscent of a thesis problem at a university, which might be entitled, "Pick out a hillside and plan in detail for a town of 10,000." One of the complications was that before the town of 10,000 grew even to 6,000, the plans had to be revised to accommodate a town of 20,000, and before 10,000 had moved in, the plans had to be revised upwards again. The population of Oak Ridge reached a peak of 75,000 during the war.

Unconventional engineering

Civil engineers, in common with all of us, have had to learn a few new concepts. In addition to the dicta of the famous Modulus of Mr. Young and the Law of Mr. Hook, engineers have had to learn what is meant by neutron cross-section capture, Compton scattering, half-value layer, sky shine, induced radioactivity, phase transitions, and a host of others. But this has not been an insurmountable task. Basically, the most important contribution that the civil engineer can bring with him to this new field is a thorough knowledge of the fundamentals of his own profession—strength of materials, hydraulics, sanitation, etc., and I suppose, a certain spirit of adventure needed to tackle a new job with brand new design criteria, dealing with radioactivity which cannot be seen, smelled, heard, tasted, or otherwise sensed except by special instrumentation.

The atomic age has made exacting demands on the civil engineering profession. To operate some of these reactors properly, civil engineers have been asked (with a perfectly straight face) to design and build steel tanks with joints (as in the case of the atomic submarine) that will not leak more than one drop of liquid in 500 years. The demand has arisen for buildings with extremely heavy walls and with heavy steel plates laced into them. Civil engineers have been asked to handle, not ordinary concrete, but what is called heavy and super-heavy concrete, in which part of the aggregate is replaced with crushed barium sulphate rock or with heavy steel punchings. Sewers have been developed that will not corrode; filter beds are available that will take out radioactivity, as well as bacteria and mud; ion exchange resins will remove soluble salts from water, not merely the familiar calcium and magnesium, but the more difficult ones such as sodium and potassium, and even the negative ions such as chloride and nitrate.

New waste-disposal problems

Considerable progress has been made in the handling of sewage from atomic energy plants. It is interesting to note that much of the conventional experience in the field of water and sewerage treatment, for example, can be carried over directly. Some of the outstanding work in this field is being performed by the Sanitary Engineering Department of the Johns Hopkins University in Baltimore under Prof. Charles E. Wrenn and at MIT under Prof. Rolf Eliasson, M. ASCE. It has been found that, in the low-level radioactive wastes, from 90 to 95 percent of the radioactivity can be removed by means of standard water purification processes, such as soda alum treatment. Ion exchange resins have been developed in this field and have been studied in various parts of the country to remove directly, by means of physical adsorption, much of the radioactivity present in the discharge wastes.

But the high-level wastes, those resulting from the chemical separation of uranium and plutonium from the fission products at Hanford and other places, are the ones that are more difficult to handle. Admittedly here the perfect solution has not been found to the problem of waste disposal, and such fission products are at present stored at Hanford and elsewhere in underground tanks. Eventually it is hoped that a satisfactory method of waste disposal can be found because one cannot continue indefinitely to build tanks to hold waste materials. The Commission has an active research program under way to improve our waste disposal techniques.

Civil engineers also have considerable responsibility for site location and plant layout. In the Oak Ridge construction, some 90 sq miles of sparsely inhabited countryside was taken over and fenced in. This became known as the Manhattan Engineering District. As at Hanford, Arco and elsewhere, there are a few buildings which of necessity must be located together as a unit, but the distance between such units may be several miles, or in some cases up to ten miles.

Obviously, if we are to have practical atomic power plants in the future, we will have to do all we can to reduce the enormous acreage of land now necessary simply to provide an "exclusion area" for the reactors. The view has been expressed that it may be possible to operate an atomic reactor in a location in which we now operate a conventional power plant.

It is interesting to note, therefore, that one type of construction for housing a reactor is not a building at all in the conventional sense of the word. The structure which houses the atomic submarine engine at West Milton, N.Y., is a hollow sphere, with an inside diameter of 225 ft. The steel is approximately $1^1/_2$ in. thick, and the entire vessel had to be made leakproof. The Chicago Iron and Bridge Company were the successful builders of this "building." From this type of plant "layout," much useful information will be gained concerning the necessary size of the exclusion area.

In the field of heat transfer, for example, if an engineer wishes to cut down by one-half the quantity of heat escaping from a hot object, he simply doubles the thickness of the insulation and designs the supporting members to carry twice the load. With radioactivity, the absorption of gamma radiation in particular is logarithmic, and instead of doubling the original thickness of shielding, it is necessary to add one more "half-value layer." In shielding against the gamma radiation from Cobalt-60, $^3/_8$-in. lead will reduce the transmitted intensity to one-half the incident value. If for example in a structure that already has 5 in. of lead shielding, it were found that twice as much radioactivity were coming through as was desirable, it would be necessary not to add another 5-in. thickness of lead, but only $^3/_8$ in. The strength of the supporting girders and beams would then be designed to support, not 10 in. of lead, but $5^3/_8$ in.

Resourcefulness in demand

Civil engineers are a very resourceful group, and together with their counterparts, mechanical engineers, are probably responsible for producing some of the weirdest gadgets on the face of the earth. Let's assume that we have a simple task of emptying the contents of one tank into another. We could siphon from one to the other if we wished, or hook on a pump, or simply locate one tank on top of the other and reach in to turn a valve.

When we add radioactivity to the problem, things really become complex. It may be necessary, as it is in a number of cases, to put a concrete wall completely around the two tanks—top, sides, and bottom. Hand-operated valves must be replaced by remote-control gadgets. To make the problem more interesting, the operator of this simple transfer unit may not even be allowed to look at it directly. He must perform all his operations by looking through a periscope, or a liquid zinc bro-

mide viewing window, or in some cases by means of stereoscopic television.

The civil engineer and the mechanical engineer have produced many such handling miracles.

Engineering also benefits

Not all these demands are one-way propositions, however. Out of the fruits of the atomic energy program have come tools that will aid the civil engineer. For example, a device has been developed that will determine very simply the density of a soil in terms of pounds per cubic foot. This device operates on the principal of a radioisotope density gage and does not disturb the soil. Another device uses a source of neutron radiation to determine the percentage of moisture in the soil. Thus a combination of the two devices can be used to measure both density and water content. This is extremely important in highway construction and particularly in the building of airport landing strips.

The above is one example of how a seemingly unimportant observation by physicists can be applied directly by engineers. The discovery was made long ago that neutrons (which have approximately the mass of a hydrogen atom and no charge) are slowed down when passing through hydrogenous material, and physicists have measured the degree of absorption of neutrons by hydrogen atoms under various conditions. It was a short step, therefore, for an engineer to take this scientific knowledge and translate it into something practical.

Radiographic cobalt has been used to ensure that welds are made tight, and maintenance services are offered by several companies to determine the thickness of pipes carrying water or other fluids under service conditions, without the necessity of shutting off the flow or getting at the inside of the pipe to make the measurement.

It may be of interest to mention that radioisotopes have been used in the field of sanitation to assist in mosquito control. Larvae are fed on nutrient solutions containing radioactive phosphorus 32. Soon they hatch into adult mosquitoes which, of course, are radioactive. It is then a comparatively simple matter to determine how far mosquitoes will fly from a given source of infestation by capturing a number of them with a net and then counting the relative number of radioactive and nonradioactive mosquitoes. The tests show that on the average, mosquitoes fly not more than a couple of hundred yards from their original resting place. Just think what this could have meant to the builders of the Panama Canal, when one of the problems in conquering and defeating the anopheles was to judge how large an area had to be cleaned out to guard against infestation.

Radioisotopes have also been used to trace the flow of underground streams and to measure to what extent the ground can absorb runoff wastes of various kinds.

Engineers build atomic power plants

The civil engineer continues his role as the builder of atomic energy power plants, the first of which is rising near Pittsburgh.

In what way does an atomic energy power plant differ from a conventional power plant? The fire-box for thermal fuels such as coal and oil would be replaced by a nuclear reactor. This is essentially the difference between an A-power electric installation and one of the more familiar sort.

In spite of its relatively poor prospects for economic nuclear power, the 60,000-kw pressurized water reactor at Shippingport, Pa., authorized by the Commission in July 1953, is being built because it is an early type for which the technology is sufficiently far advanced. The development, design, and construction of the reactor part of the plant has been assigned to the Westinghouse Electric Co. The Duquesne Light and Power Co. entered into a joint venture with the AEC to construct and operate the electrical generating part of the power plant, and to operate and furnish the labor for operating the nuclear part. The former also agreed to assume \$5 million of the research, development, and construction costs of the reactor part and to purchase the steam generated. The project will provide much-needed information in the field of nuclear engineering, and the results and experience gained will benefit the other four approaches.

What savings can be expected from the use of A-power? Probably they will correspond only to those attributable to the difference in the costs of generating heat from A-fuel and from conventional fuel. One may say, as a rule of thumb, that the cost of the fuel in terms of heat units at the fire box averages about one-half the total cost of generating power at the station. Various parts of the United States differ in fuel costs as do various parts of the world.

Statisticians have computed that in the "average" finished article which is sold to the public, the cost of the electric power used represents about 3 percent of the selling price. This figure ranges up to 30 percent, for example, in the ceramics industry and would be vanishingly small for agricultural products. Nevertheless, the quantity of electric power consumed in this country is so large that every saving of $^1/_{10}$ cent per kwhr means a nation-wide saving of about \$430 million per year. The race for competitive, economical power is definitely on, both in this country and elsewhere.

With the passage of the Atomic Energy Act of 1954, the climate for the entry of American business into industrial atomic energy was greatly improved. Less stringent clearance procedures, designated as "L-type" clearances, were instituted. "Access" agreements made it possible for companies to satisfy their initial desire to see whether atomic energy might have application to their lines of business. Establishment of a Division of Civilian Applications is bringing closer the day when atomic energy will take its place within the normal framework of the nation's economy.

Opportunities for civil engineers

What about the engineering firm that boasts it has been in business 50 years or more and whose senior personnel graduated from school better than 30 years ago? What can they, or should they, do about entering the atomic energy field? Some of them may feel that it's too late to teach an old dog new tricks. This may be true in some cases. A man is commonly said to be as old as his arteries, but more correctly, in my opinion, a man is as young as his capacity to learn.

If he wants to learn, or wants some of the bright young men on his staff to learn for him, then I think such an engineering firm might want to consider the desirability of getting into the field of atomic energy in some way. Aids have been established, and the Division of Civilian Applications is one of the contact points to help such firms get started. The Oak Ridge School of Reactor Technology at Oak Ridge, Tenn., offers a one-year course for qualified engineers to learn how to build, repair, design, and operate nuclear reactors. The Industrial Participation Plan, whereby industry may send one or more of its men to work in the Commission plants, is another mode of entry, as is affiliation with a power study group.

The opportunity to learn is there, and it is the engineer's turn to pick up the ball and go with it if he wants to, for the place of the civil engineer in the atomic age is whatever he chooses to make it.

PHOTOGRAMMETRY

Today geologist's first step in search for oil or minerals is usually a study of aerial photographs. Anticlinal structure is revealed by this aerial photo at a glance.

LEON T. ELIEL, M. ASCE, President,
Fairchild Aerial Surveys, Inc., Los Angeles, Calif.

—at your service

It is a bit of a surprise to the photogrammetrist to learn, as he does from time to time, that engineers are still "discovering" the value of aerial photography and photogrammetry. American engineers have actually been using photogrammetry for more than thirty years. With apologies, then, to those who are unfamiliar with the fundamentals of photogrammetry on the one hand, and to those who find it absurdly elementary on the other, this article will attempt to touch on some of the more recent uses of aerial photography and photogrammetry in civil engineering.

It may be stated for the record that aerial photography in the United States started about 1919, having received some impetus in World War I. By 1923 some contour maps were already being utilized which had been prepared by photogrammetric methods. It was in that year that the first contour map for a dam site was prepared by photogrammetric methods, and that the first reservoir capacities were likewise determined from photogrammetric maps.

In 1927 photogrammetrically made contour maps were first used in the development of an oil field, and in 1931 the first real estate subdivision was engineered from such a map. In 1931 the first highway was designed from a photogrammetric map, and from that day to this there has been a constant broadening in the acceptance of aerial photography and photogrammetry across the board for many types of engineering projects.

Today most U.S. Geological Survey maps are compiled by aerial photography and photogrammetric methods. Likewise, most of the maps and charts compiled by the Coast and Geodetic Survey, the Hydrographic Office of the Navy, the Air Force, and the Forest and Soil Conservation Services, utilize photogrammetric methods whenever the aerial photography is available. The Army Map Service does an extensive job of photogrammetric compilation around the world. In these various government agencies alone there are hundreds of fantastically precise stereoscopic plotting machines.

Photogrammetry, a growing industry

As a further index of the extent of interest in these subjects, there is an outstanding national organization, with many local chapters—the American Society of Photogrammetry, with more than 3,000 members and a quarterly journal of more than 200 pages per edition. Thus the child of World War I today finds itself a robust adult. In addition to its use by the great government agencies, photogrammetry is practiced by many individuals and by mapping corporations measuring their employees by the hundreds.

What then are all these people doing that is useful to the engineer?

To begin with, the state highway departments of at least 30 states now locate and in many cases design their highways from photogrammetric maps. The most usual practice is to start out with aerial photography along the proposed routes at a scale of perhaps 1 in. = 1,000 ft. With this photography and correlating ground studies, the probable center line of the highway is located. Then a topographic map is prepared from the same pictures at a scale of 1 in. = 200 ft, with 5-ft contours. This is often followed by a subsequent flight at a larger scale, such as 1 in. = 400 ft, and a contour map is produced at a scale of 1 in. = 40 ft or 1 in. = 50 ft, with 2-ft contours. These maps are frequently accepted by both the state and the contractor as the basis for quantity payments, and for estimating purposes.

How accurate is a contour map?

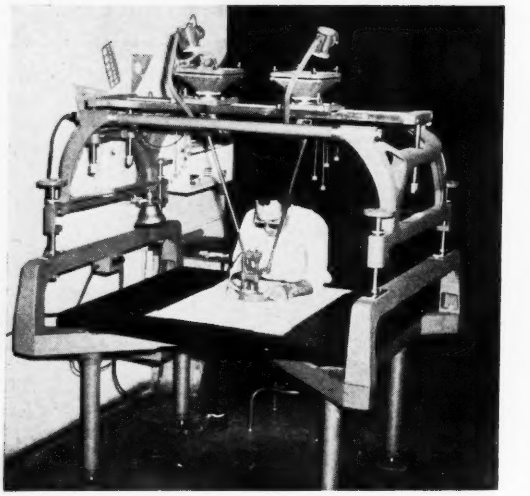
In approaching a photogrammetric survey of this kind—or in fact almost any kind—it must be kept in mind that a contour map can be accurately drawn from aerial photographs only in areas where the ground is visible. Thus in very dense evergreen timber the photogrammetrist has trouble. On the other hand, throughout the eastern part of the United States most of the timber is deciduous, and photography in such areas, taken after the leaves have fallen in the fall and before they have come out in the spring, and at times when there is not too much snow on the ground, is usually quite satisfactory for photogrammetric purposes.

The standard specification that is almost universally adopted for this type of survey reads as follows:

"Ninety percent of all contours shall be correct within one-half contour interval, and no contour shall be in error by more than one full contour interval. All well defined cultural features shall be shown on the map within 0.025 inch of the correct position. No such feature shall be more than 0.05 inch from its true position."

It is usual for photogrammetric contracts to carry a so-called "brush clause." This is to cover the cases where the ground is obscured by vegetation. A very misleading specification has been extensively used in photogrammetric contracts which provides that where the ground is obscured by vegetation the maximum error shall be "not more than twice those heretofore specified." This is unfortunate because in many places where solid trees cover an area all the way from 30 or 40 ft to 200 ft in height, it is quite impractical for the photogrammetrist to meet such a specification. The result is that either there must be a tacit understanding that the photogrammetrist is really not expected to meet it, or else he must go in on the ground and do field completion by ordinary surveying methods, which often will increase the cost of the map by many fold.

Taking the opposite view are some engineers who may tend to be on the purist side, and say, "What is the use of having a map unless you know it is uniformly good?" In answer to this, let us consider a topographic map made for a highway location and covering a strip of topography one mile wide. The highway is actually going to be perhaps 100 ft wide. Or, in other words, the highway is only actually going to be constructed on 2 percent of the map. If it so happens that as much as 10 percent of this map is



← Stereoscopic plotting machine is used to draw contours from aerial photographs. By means of corresponding colored filters in his eyeglasses and the two projectors, operator sees topographic model in three dimensions. Pencil attached to movable table draws contour line when he moves a dot of light on the image at constant elevation. This is Kelsh Plotter, one of most universally used plotting machines.

Photogrammetry is today often used to inventory stockpiles, since ground control need be done only once, and thereafter whole inventory can be taken instantaneously no matter how many stockpiles are involved. Here typical stockpile has been contoured to measure its volume. Solid lines are 2-ft contours, and intervening dashed lines are 1-ft contours.

obscured by spots of evergreen timber, the chances are only one in five that the highway will ever be located within the obscured area. To do this obscured 10 percent by ground methods (it is always very expensive to work in timber areas) would usually more than double the cost of the map as a whole.

It therefore seems more logical that the client should request the photogrammetrist who is making the map to show all areas of doubtful accuracy by a broken or dashed line. If in the unlikely event that the final location of the highway actually does go through any of these dotted areas, the client himself can do a little field completion work to make certain that the contours of the map are good enough for his purposes. In this matter, the "tongue-in-cheek" type of arrangement which so often exists now between highway engineer and photogrammetrist can be avoided. A situation which is professionally healthier and economically sounder would exist if the contract specified that in obscured areas the photogrammetrist is merely expected to do the best he can, and indicate the uncertainty by an appropriate symbol.

Other uses of photo interpretation

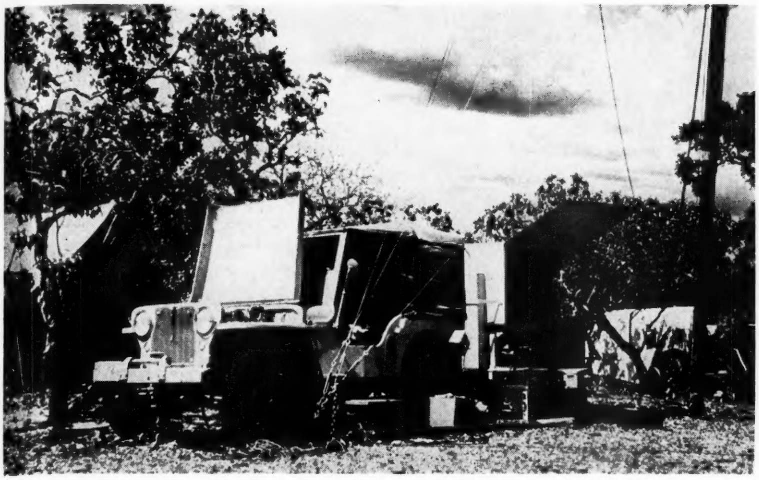
Today, along with the actual contour maps which are being made by photogrammetric methods, another most valuable service is being rendered to the engineer through photo interpretation. By a study of the aerial photographs, a photogrammetrist can locate areas near the project where, for example, sand and gravel can probably be found. The photo interpreter can also indicate areas that are likely to be excessively expensive for highway construction, such as stretches of heavy rock or of swamp, and of course areas of high economic value. Photo interpretation has also been applied to such problems as the study of limestone areas and areas that are heavily faulted, to determine probable leakage from a reservoir.

Today many open-pit mines and stockpiles are receiving periodic photogrammetric treatment to determine quantities of excavation and quantities in inventory. This kind of problem is most susceptible to photogrammetric solution because the ground control work has to be done only once. Subsequent studies involve merely the flying to take new pictures and the plotting and computing of the quantities. This is done by planimetering the areas and applying the units of weight and value for each particular kind of material. Besides reducing the cost (often), this approach has the great advantage of taking the whole inventory at one particular instant of time. In a storage area comprising dozens or hundreds of stockpiles, any inventory made by a conventional ground survey is apt to be complicated by the constant addition and removal of material.

Photogrammetry has recently been used in studies for the realignment of railroads. While, in the United States at least, very few actual new railroad locations are being made, extensive realignment work is under study and in progress. Preliminary studies may be made by photo interpretation from vertical aerial photography and a stereoscope. All physical and cultural features can be studied. After a tentative route has been selected, a contour map is prepared photogrammetrically and the actual location and design are based on this map augmented by very detailed ground surveys made at critical points such as bridge abutments. Railroads also use photogrammetric maps, and particularly aerial photography, for studying their rights of way, to take a complete inventory of the physical features of the trackage as well as to show available property for new industries which can be readily served by the railroad. This information is used by the railroad itself, for inventory purposes, and also in approaching industries looking for new sites.

Today transmission lines, pipelines, and micro-wave tower locations are an old story to the aerial photographer and photogrammetrist. In a good many cases where the terrain is straightforward, these locations merely employ aerial photography for a detailed inventory of the terrain through which the location is going to pass. At other times, where the topography is difficult, the approach is often divided into two steps, the first being aerial photography, which is cheap and fast and which gives a good tentative preliminary location. This is then followed, for example in a transmission-line location, by a plan and profile developed from the pictures. A point which often is of value is the fact that maps for these locations can be made from the air without ever setting foot on the ground. The airplane may fly over at an altitude of several thousand feet, and as far as physical features are concerned the line can be located from maps developed from these pictures without any ground work whatsoever.

Another noteworthy feature is the possibility of acquiring easements for such a location without the time-consuming and costly property surveys that are conventionally employed.



Shoran ground station, seen in operation in Venezuela, uses jeep engine for power to operate electronics gear in trailer. Base of shoran antenna mast appears at right.

Shoran—valuable tool

In exploratory surveys, where it is very difficult and costly to get around to establish ground control by conventional survey practice, a new radar system developed in World War II, known as shoran, is employed. Shoran is a means of keeping an airplane located at all times in relation to certain ground stations. If, for example, the airplane is flying at 30,000 ft, it will send out a radar signal which is picked up by two ground stations located on known ground points, and relayed back to the airplane. The time it takes the signal to travel to the ground station and return is translated into distance. For the two ground stations there are two dials, each constantly recording the distance to the respective stations to the nearest hundredth of a mile (50 ft, which is first-order survey accuracy for 250 miles). As the airplane takes an aerial photograph, a recording camera at the same instant records the shoran dials so that the exact position from which the picture was taken can be computed (three known sides of a triangle).

Shoran is a line-of-sight operation, and while the range is theoretically over 250 miles for an airplane at very high altitude, such as 30,000 ft, a practical limitation is the power available in the airplane. This will probably limit the distance at which the shoran can be operated to perhaps 200 or 250 miles from the ground stations, depending on conditions. The distance a shoran operation can be conducted is theoretically defined in the following formula:

$$D = 1.49\left(\sqrt{H} + \sqrt{K}\right), \text{ in which}$$

D = distance from ground station to aircraft in miles
H = height of aircraft, in feet
K = elevation of ground station in feet

Exploration by airplane

It may be interesting for the civil engineer to note, even though it has no direct bearing on his profession, that in recent years a number of new methods of airborne exploration have come into extensive use. First there is the well-established application of aerial photography to the study of geology. The exploration geologist uses aerial photography almost universally as the first step in his search for oil or minerals. If he anticipates that there will be no manifestation of the deposit on the surface of the earth, but only subsurface indications, he will turn to other means, such as the airborne magnetometer, which detects some deposits, such as magnetite, by direct indication. The magnetometer is also helpful in exploration for oil because of the magnetic properties of the basement rock, permitting the geologist to determine something about the basement configuration, which frequently is the controlling factor in the formation of oil traps.

Another new method for finding base metals, especially in primitive, pre-Cambrian areas of the world, is the electro-magnetometer, a device which measures the conductivity of the materials in the earth beneath the airplane. Areas of high conductivity are good places to look for lead, zinc, copper, and similar metals. The airborne scintillation counter detects the gamma rays which are given off by radioactive materials such as uranium and thorium.

Even where topographic indications fail to reveal a deposit, geologist may still use aerial methods. Aircraft shown is performing a magnetometer study. "Bird" housing sensitive detecting element is trailed on 100-ft cable to avoid effects of aircraft's engines or structure.

Probably hundreds of small aircraft have been so engaged during the past two years.

Such activities may be characterized as exploration to begin with, but they usually involve civil engineering ultimately.

Today the civil engineer who is confronted with the problem of locating a road or a railroad, of studying a watershed for reservoir and dam sites, of studying an area for a possible irrigation project; who is confronted with the problems connected with a transmission line or pipeline, or is making city planning studies—turns to the airplane and the photogrammetrist for his maps. There are not many things a civil engineer does without the help of some kind of survey or map information. It is for this reason that today scarcely an important engineering office in the world is without its files of aerial photographs and photogrammetric contour maps, which form a part of the dossier on every important project.

GEOPHYSICS AS A TOOL IN SOIL MECHANICS

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Predictions of how underground soils will react to a construction plan are limited by the degree of accuracy that can be obtained in ascertaining the extent and properties of such soils. This is still true despite the improvements of recent years in soil testing and refined analyses. Geophysics offers a promising tool in collecting definite and reliable subsurface data. Although the principal application of geophysics to soil mechanics engineering at present is in explorations, direct measurements of specific properties can be made and probably will be increasingly useful as equipment and technique are improved.

Geophysical surveys are accomplished by surface measurements of subsurface physical properties. The subsurface conditions are deduced from the surface measurements. Seismic methods, electrical resistivity methods, measurements of vibrations, and radioactive tracing of subsurface seepage are among the techniques that have been successfully applied to civil engineering problems. The first two methods require that the physical properties of the subsurface materials vary enough to give different measurements at the surface; the others attempt to make direct determinations of critical conditions.

The usual approach to soil explorations has been through excavations, test pits, and borings. Test pits and borings, when properly made, permit definite determinations of soil conditions at one point. Aside from the expense, the basic limitation of these methods is that, to get a completely accurate three-dimensional representation of an entire site, it is necessary to excavate and examine it all. But if this were done, then the conditions about which information was desired would no longer exist.

Borings always leave unexplored areas, and a great deal of experience is not needed to make it evident that unforeseen underground conditions spell trouble in construction. It is true that worthwhile deductions can be made if boring programs are planned wisely and carried out under the direction of an engineer who understands what soil conditions can mean to a planned scheme of construction. However, the detail required is expensive and there is always the unexplored part that leaves the engineer in doubt. The amount of doubt directly affects the allowance for ignorance in foundation designs. This allowance costs money in completed foundations. Geophysical exploration, which has been so successful in the search for oil, offers considerable hope of reducing the doubt in engineering investigations.

Seismic methods

Detailed descriptions of the equipment and procedures for refraction seismic explorations may be found in a number of publications, among them *Geophysical Exploration*, by C. A. Heiland (Prentice-Hall, New York, 1946), *Seismic Prospecting for Oil*, by C. H. Dix (Harper & Bros., New York, 1952), and *Introduction to Geophysical Prospecting*, by M. B. Dobrin (McGraw-Hill, New York, 1952). Briefly, the velocities of

FIG. 1. An explosion is one source of energy for measurement of wave velocities by seismic methods. This exploration is at site of an aluminum reduction plant.

propagation of an induced energy are measured for various layers of materials. The energy is induced by an explosion (Fig. 1) or sledge-hammer blow; the velocities are measured with geophones on the surface. From these velocities the depths to the materials in question are estimated.

This method carries with it certain limitations: (1) To distinguish between different soils, their velocity of propagation of energy waves must be significantly different; (2) to establish the extent of the soils, they must be in layers with relatively plane surfaces, and the lateral extent must be several times greater than the depth; and (3) to distinguish the different soils, in most cases the deepest layers must have the greatest velocities.

Seismic explorations are valuable in two principal applications—in discovering underground changes and irregularities without defining the extent and characteristics of the bodies, and in determining the extent of materials of different characteristics. Each of these applications may be made during either the preliminary planning phase of an investigation or during the final phase, when underground details must be determined.

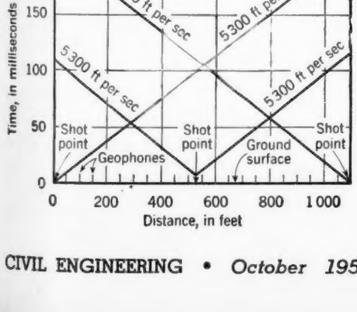
These uses probably can best be illustrated by describing actual cases. There is less difficulty in interpreting seismic results when it is merely desired to find if there are any changes underground. Any velocity variation is pertinent, but deciding what the velocity variations mean is not absolutely necessary. For instance, it was desired to locate a chemical plant somewhere on a site of about 700 acres. The site was underlain by the sedimentary deposits found near the Great Salt Lake. This area is known to be underlain by interspersed layers and lenticular deposits of sands and very compressible clays. Previous explorations had shown random sand deposits presumed to be of sufficient areal extent and thickness and at such depths that relatively economical foundations would be possible.

While transportation, processing, and other functions indicated a preferred location for the plant, significant foundation economies would outweigh these advantages. Before the detailed explorations were undertaken, three seismic lines were run across the 700-acre site, two parallel and one at right angles to these two. It was planned that, if significant velocity variations were found at economical depths, the area of the variations would be further explored seismically and with borings in the hope of finding a useful sand deposit. The interpretation of the seismic data did not indicate any distinct underground variations. A typical chart of time versus distance, indicating underground velocities at this site, is shown in Fig. 2. The plant was located in the original preferred location, and subsequent borings confirmed the absence of any large body of sand in this area.

The use of seismic data in detailed explorations for irregularities may be illustrated by an investigation for a proposed aluminum reduction plant in Montana. Borings were put down at the corners and center of the site of a proposed process building which was to be about 1,000 ft square. The borings showed sand and gravel to depths varying from 25 to 40 ft, underlain by soft clay to very great depths. Seismic explorations were run around the periphery and across the center of the building, tying into the borings. The lower boundary of the sand and gravel layer was determined from the seismic profiles, and it was shown that there were no major irregularities between borings. It was concluded that the process building could be built with foundations on top of the sand and gravel layer, provided areal settlements were anticipated and taken into account in the design. While the structure was not built, the agreement between the seismic interpretations and the boring logs gave confidence that the data on the rest of the site were good. However, in this case it was planned to make some check borings before construction.

An excellent example of a preliminary exploration to define a bedrock surface is afforded by some recent work on a dam site in the State of Washington. Initially two borings, Nos. 1 and 2, were started at the locations shown on the plan, Fig. 3. The first seismic line (Line A) was run through these two borings. The preliminary seismic profile showed a deep depression in the bedrock beneath Boring 1, and in this boring bedrock was encountered at a depth of 245 ft. It was decided to terminate Boring 2 and move to Boring 5. In the meantime, seismic Line C had been run. Line C indicated bedrock 45 ft deep at the location of Boring 5, which encountered rock at a depth of 90 ft. This large error was not surprising, considering the preliminary nature of the work. An underground weathered joint plane may have existed in the vicinity of Boring 5, similar to that at the surface shown in

FIG. 2. Typical time-distance chart for a seismic refraction exploration shows consistent velocities throughout 1,100-ft profile at site of chemical plant near Great Salt Lake. Chart indicates homogeneity of foundation material and absence of random sand deposits in this case.



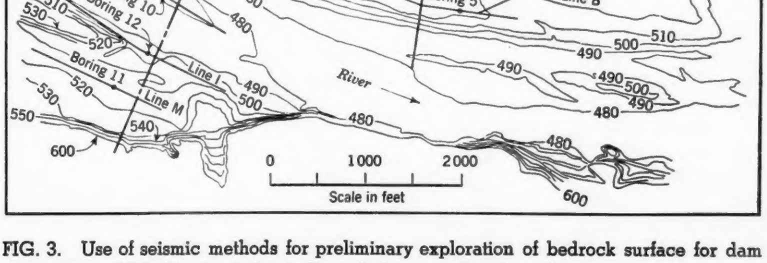


FIG. 3. Use of seismic methods for preliminary exploration of bedrock surface for dam site in State of Washington led to indicated change in location of dam axis.

FIG. 4. Abrupt changes in underground rock surface—similar to this exposed joint plane—require close spacing of seismic detectors in order to be recognized.

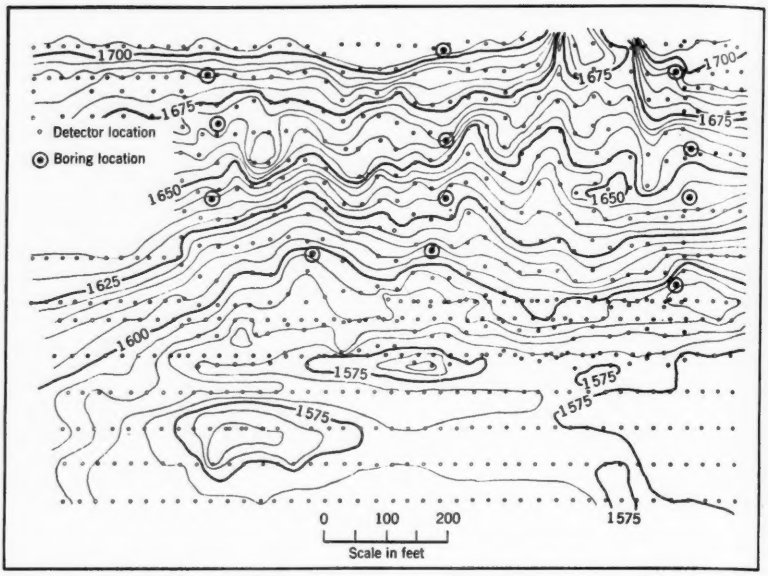


FIG. 5. Use of seismic methods to obtain final detailed data is shown by explorations at site of large plant in Midwest. Here contours of underground rock surface were mapped by running successive parallel lines about 50 ft apart, placing geophones in each line about 25 ft apart. Subsequent excavation confirmed the rock configuration obtained from the geophysical survey.

Fig. 4. Greater detail in this area could have been obtained later by closer spacing of the geophones.

Subsequently, seismic Lines L, H, and M were run. These lines indicated that bedrock was much closer to the surface north of the originally considered axis for the dam. On the basis of these results, drilling at the first location was discontinued, and the proposed axis was moved to the north as shown on the plan. Borings 9, 10, 11, and 12 were drilled and confirmed that the rock was nearer the surface at the new location. The first boring, No. 1, required three weeks to drill; Boring 5 required one week. The entire seismic job of 47,050 lin ft, including two lines not shown in Fig. 3, required $7^1/_2$ days.

Explorations at the site of a large plant in the Midwest afford a good example of the use of seismic methods to obtain final detailed data. A number of borings were drilled at the site in preliminary investigations, the closest being about 400 ft apart. One of the major structures in the plant required foundations in rock. The borings showed rock at an average depth of about 25 ft. The site was on a hillside, and it was decided to excavate all overburden and establish final foundation grade at a uniform level along the slope; this would balance the cost of rock excavation and the cost of foundation concrete to reach rock. The rock surface was likely to be uneven, but the assumption was that it could be determined by a straight-line interpolation between borings. Initial foundation excavations revealed large variations in the rock surface, making additional exploration necessary to determine the most economical foundation level. Geophysical exploration seemed the quickest and most practical means of making these determinations.

In distinction to the other investigations described here, a determined effort was made to get very accurate and detailed subsurface information. The geophones in this investigation were placed only 25 ft apart. Successive parallel lines were run about 50 ft apart. At the conclusion of the work, subsurface contours of the rock were drawn (Fig. 5). Subsequent excavations confirmed the configurations interpreted from the geophysical survey. A new foundation grade was established. The borings in this area required one month to complete. The seismic profiles required three weeks. Boring data necessary to duplicate the seismic data would have required one year with the same number of men as were employed on the seismic work, and probably would have cost ten times as much.

In addition to locating the bedrock surface beneath the major structure, seismic surveys were used for other explorations at this large site. For example, a large amount of borrow was needed for backfill. Subsurface contours gave accurate indications of the location and amount of borrow available in the plant area.

In another case, a leaking reservoir was explored. Previous explorations had thrown light on the velocities of propagation of the different formations. Seismic lines in a part of the reservoir area showed a velocity less than that of bedrock, but greater than that of the overburden. Together with surface and subsurface observations, these data served to confirm the location of fractured bedrock, and suggested that the reservoir should be grouted. Later the reservoir was successfully sealed by grouting.

In another area where a low dam, pumping station, and railroad fill were proposed, profiles were made to indicate the rock surface. At another location a decision had to be made between a bridge or a fill for a railroad. From the velocities obtained, it was certain that the supposed extensive muck deposits were not present, indicating that the fill was economically possible.

Electrical resistivity methods, which are based on the resistance of different soils to an applied electrical current, generally can be used for about the same sort of underground determinations as the refraction seismic procedure. However, on sites where one method will be successful, the other may not

FIG. 6. Shaking machine—with vibration recording equipment in foreground—has been set up on a model footing to evaluate susceptibility of a compressor building to settlement due to vibration. Conclusion was that operation frequencies would not be in resonance with natural frequency of foundation soil.

be. In the electrical resistivity method, current is applied to the ground at two points and the potential drop, or resistivity, is measured between two additional points that are spaced certain distances from the primary electrodes. Since the electrode spacing controls the depth of penetration of the current, the apparent resistivity is measured as a function of depth. This method of exploration also has certain limitations: (1) To distinguish between different materials, the resistivity must be different; (2) it is desirable to measure only materials of shallow depth which have considerable lateral extent. This method was used in exploring the site of a proposed building to be located over some limestone deposits in Missouri. The resistivity results were useful in determining the limestone surface between borings, but in this instance were inconclusive in locating caverns in the limestone. These were later found by borings.

Surface vibrations measured

Measurement of surface vibrations is a particularly interesting procedure and one which it seems should yield accurate results. The ground is elastic; it resists an applied force by a force that is about proportional to its displacement. Therefore, its oscillations exhibit simple harmonic motion. Since it is possible to relate simple harmonic motion to limits of amplitude, frequency and direction of motion, seismograph recordings of actual ground motion may be evaluated for the effects of these movements on engineering structures.

Two cases might be cited. In one case, a laboratory building was to be built on fill over some soft bay deposits near San Francisco. A railroad track was about two hundred yards away. A recording seismograph was placed on the floor of a small building near the proposed location. The vibrations transmitted by passing trains were measured. It was concluded that sensitive laboratory balances could not be used unless specially mounted to reduce vibration.

In another case, a chemical plant was to be located on a site underlain by relatively uniform deposits of sand in Torrance, Calif. It was decided to level up the site with compacted fill and place all foundations at a relatively uniform depth—some on fill, some on the natural soil. To evaluate the susceptibility of a compressor building to settlement due to vibration, a shaking machine was set up on a model footing (Fig. 6), and in so far as possible the frequency of vibrations, contact weight, unbalanced forces, and other conditions were made similar to the proposed compressor design. When the shaker was run, the amplitudes of motion of the footing were measured by an electronic vibration recorder. From these measurements, it was concluded that operation frequencies would not be in resonance with the natural frequency of the foundation soil. No settlements were observed in the natural soil but a small settlement was measured in the fill (which incidentally had been compacted to densities as great as the natural soil). It was concluded that settlement of the completed compressor building would be within tolerable limits.

Tracers show water movement

Radioactive tracers as used today are synthetic isotopes which may be distinguished by their radioactive emissions. It is possible to measure and record these emissions with radioactivity counters, such as the Geiger tube and scaler. A most interesting attempt to trace water movement with radioactive tracers was made on a landslide problem in Berkeley, Calif.

As with many landslide problems, the areas of water movement and depth were critical. Radioactive isotope solutions were injected in borings near the top of the slide and water samples taken from borings near the bottom. When the samples were analyzed, only one positive indication of the radioactive isotopes was discovered. These observations assisted in confirming the conclusion that the water flow was channelized at random locations. Drainage was therefore designed to intercept all possible channels. Shafts were drilled and tunnels cut between them, both shafts and tunnels being filled with pervious material and connected to a drain. There have been no measurable movements since this drain was installed.

Geophysics for soil mechanics problems

Geophysical methods offer attractive possibilities in connection with soil mechanics investigations. The most fascinating possibility is to make all measurements at the surface without the necessity of delving beneath it to get information about underground conditions. To make the most of the possibilities, it is necessary to understand the limitations of the methods, to recognize which procedures are most useful for the various applications, and to be familiar enough with the techniques to carry out the investigations expeditiously. Experience gained in applying geophysical principles to soil mechanics problems is valuable in planning subsequent procedures. It is probable that the maximum application, and hence the maximum benefit, from geophysical methods will be realized fully only by perseverance in adapting known methods to practical problems.

Low-alloy, high-strength steels for bridges

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Graceful lines of main cables emphasize strength and stability of towers and stiffening girders of Missouri River Bridge, at the Paseo, Kansas City, Mo. Changing the type of steel from silicon to low-alloy is estimated to have saved 200 tons in towers and stiffening girders on this four-lane highway structure completed in 1954.

Development of low-alloy, high-strength steels for bridges was suggested by members of the American Society of Civil Engineers almost a half century ago. A paper entitled "Nickel Steel for Bridges," by the late J. A. L. Waddell, Hon. M. ASCE, in the 1909 ASCE *Transactions*, presented results of chemical and physical tests, design specifications and comparative costs of nickel steel, carbon steel, and mixed steel structures. The extended discussion of the paper pointed out the increased deflection and secondary stresses resulting from the use of nickel steel, its advantages for short as well as for long spans, and the economy resulting from its use. Another paper by the same author, "The Possibilities in Bridge Construction by the Use of High-Alloy Steels," in the 1913 ASCE *Transactions*, indicated the economic advantages of using alloy steels having elastic limits ranging from 50,000 to 100,000 psi.

One of the obstacles to the general use of nickel steel forty years ago was the reluctance of the steel manufacturers to guarantee the elastic limit of 60,000 psi suggested by Waddell. It is interesting to note that the present specification for nickel steel (ASTM-A8-46) calls for a minimum yield point of only 55,000 psi. Another obstacle was the excessive increase in pound price over that of carbon steel. Presumably this was due to the manufacturers' concern over the lack of a market for rejected material. Hence the adoption of some other alloy steel was indicated.

Silicon steel was developed about 1916 and was first used in the 720-ft simple-span trusses of the Chicago,

Burlington & Quincy Railroad bridge across the Ohio River at Metropolis, Ill. The essential chemical difference between silicon steel and structural carbon steel is an increase in the carbon content to 0.4 percent and in the manganese content to 0.7 percent, and the addition of 0.2 percent silicon. The minimum yield point is 45,000 psi, and the ultimate tensile strength is 80,000 to 95,000 psi. The permissible unit stress in tension is 24,000 psi, one-third higher than that for carbon steel. Since the cost of silicon steel in place is only 10 to 15 percent more than that of carbon steel, there is considerable economy in its use. Hundreds of long-span fixed highway and railway truss bridges and numerous movable bridges have been built of this material since its introduction. It has also been used for many simple and continuous girder spans, since its greater strength has brought about an increase in the permissible span length.

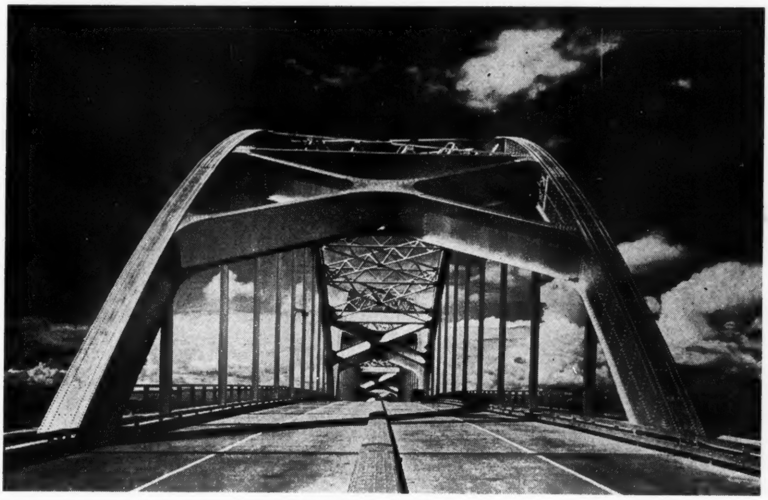
Low-alloy steel introduced in 1933

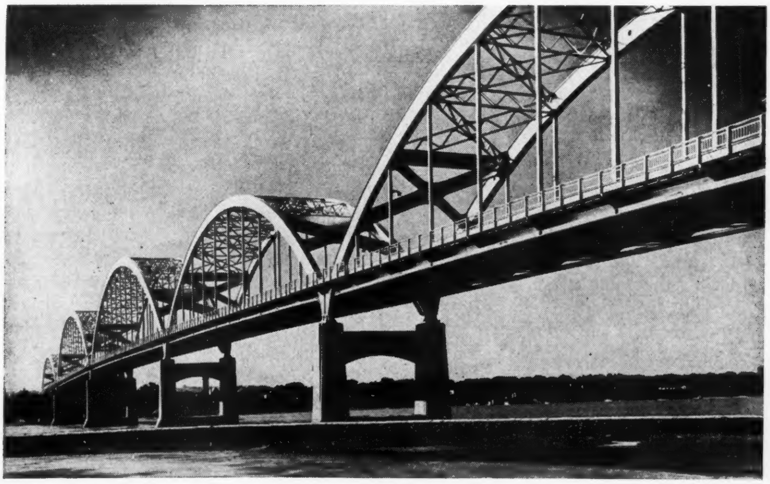
Low-alloy steel was first introduced in 1933 in the construction of transportation equipment. Since that time, numerous proprietary steels of varying chemical composition have been developed for use in structures. The increase in yield point is obtained by using moderate amounts of alloying elements. The standard specification for this class of steels, ASTM A-242, controls the chemical composition only to the extent of limiting the carbon content to 0.26 percent, the manganese to 1.30 percent, and the sulfur to 0.063 percent in the check analysis. The elements added to increase the stength of low-alloy steel also increase its resistance to atmospheric corrosion.

Low-alloy steel (ASTM A-242) was first specified for general use in bridge construction in the 1949 AASHO Standard Specifications for Highway Bridges. For thicknesses of $^3/_4$ in. and under, the minimum yield point is 50,000 psi and the permissible unit stress in tension is 27,000 psi, 50 percent higher than that of carbon steel. Its cost in place is only about 15 to 20 percent greater; hence it is economical to use in long-span riveted girders and trusses.

For thicknesses of metal over $^3/_4$ in. to $1^1/_2$ in. inclusive, the minimum yield point is 45,000 psi and the permissible unit stress in tension is 24,000 psi. The flanges of rolled beams from 24 WF 84 to 36 WF 260 fall in this thickness range. Since the design stress is the same as that for silicon steel and the cost is somewhat greater, there would seem to be no advantage in using rolled beams of low-alloy steel. However, another characteristic of low-alloy steel is its weldability. This suggests its feasibility for composite-beam highway bridges, since the interaction through shear lugs of the concrete slab and the steel beam increases the stiffness to such an extent that the permissible live-load deflection will not be exceeded. Furthermore, cover plates needed on the bottom flange may be welded with no loss of net section.

Fabrication of silicon and low-alloy steels by riveting introduced new problems in the shops since their equipment was designed for fabricating carbon steel. The thickness of metal to be sheared or punched is an inverse function of the yield point of the steel. In such operations as drilling, reaming and milling, the rate of speed or feed is reduced to approximately 75 percent of that for carbon steel. In the case of silicon steel, edges flame-cut by hand require special treatment by milling,





In Mississippi River Bridge at Rock Island, Ill., silicon steel was used for box-girder arch ribs and horizontal ties, and carbon steel for floor system, bracing, and hangers. If ribs and ties had been of carbon steel an estimated 1,200 tons additional would have been required. Note attractive effect—achieved by simple treatment of basic structural elements. Solid-web, full-depth portal bracing contrasts with lacy intermediate bracing to give open appearance overhead. This four-lane highway structure was completed in 1940.

chipping or grinding, and edges flame-cut by machine must be softened after cutting.

Fabrication of low-alloy steels by welding presents no problems not encountered in welding structural carbon steel, since they possess good welding characteristics. Silicon steel is not considered weldable for use in bridge construction.

Secondary stresses no serious problem

It has been pointed out in the past that the use of higher design stresses in alloy-steel trusses results in greater truss deflections and increased secondary stresses. For a given truss configuration, the secondary stresses are a direct function of the primary unit stresses in the members and their depth-length ratio. Thus, if the depth-length ratio is kept constant, the secondary stresses in two trusses of different steels carrying the same load will be directly proportional to the primary unit stresses, which are in turn proportional to the respective yield points of the two steels. Secondary stresses due to truss deflection are therefore of no greater concern in alloy-steel trusses than in carbon-steel trusses.

Recent changes in specifications and trends in design also have had a mitigating effect. The use of a parabolic formula for the allowable stress in compression members permits a relatively higher stress in members of increased slenderness ratio than did the old straight-line formula. Hence shallower compression members can be designed with little loss in economy. Also, trusses generally are now made of the Warren or Pratt type with long panels, instead of the subdivided type with short panels. Decreasing the depth and increasing the length of the members both tend to reduce the depth-length ratio and consequently the secondary stresses.

For example, the Sciotoville Bridge built in 1917 is a continuous truss having two spans of 775 ft. The panel length of the subdivided Warren truss is 38.75 ft. The bottom chords adjacent to the piers, being 50 in. deep, have a depth-length ratio of 0.107, and the calculated secondary stress is 21,400 psi. The writer recently calculated the secondary stresses in a highway cantilever bridge with a 620-ft main span and 310-ft ends spans, and with the same panel length as the Sciotoville Bridge—38.75 ft. The maximum stress of 5,700 psi occurred in the low-alloy steel top chord in the anchor arm, two panels away from the main pier. The depth-length ratio of this 28-in.-deep chord is only 0.061.

Some concern has also been expressed in the past about problems of elastic stability involved in the design of girders and compression members of high-strength steels. Extensive research in this field has established the required ratios of width to thickness for plates based on the yield point of the material. These are included in the design specifications, and designs made accordingly will have a sufficient factor of safety against buckling.

Weldability may point to trend

Most bridges being built at present are of riveted construction. The weldability of the low-alloy steels may presage a change to welded construction. The current AASHO Standard Specifications for Highway Bridges permit welding for the fastening of cover plates to rolled beams and for the shop fabrication of all-welded plate girders.

Another clause in the specifications (3.6.14) states that low-alloy steel plates shall be not more than $1^1/_8$ in. thick. This would seem to preclude the use of low alloy steel for long-span girders, since the required flange thickness would be 2 in. or greater if the girder is fabricated of only two flange plates and a web plate. It would permit the fabrication of a welded girder consisting of a web plate with multiple flange plates, each plate being fillet-welded to the next. Such construction is similar to riveted construction, and by lap splicing of the plates, the cutting of the complete flange section at one point is avoided. The specifications reflect a reluctance on the part of bridge designers to use single plates as girder flanges which are spliced at points of change in thickness by a butt weld. Development of generally accepted procedures for proving the reliability of butt welds will undoubtedly result in the increased use of welding for girder spans.

Truss members at present are either rolled beams or a riveted assembly of plates and shapes. It seems feasible to weld together three plates to form an H-section, or four plates to form a box section. Since these plates will be connected by continuous fillet welds, there should be no objection to this method of fabrication in either carbon or low-alloy steels.

About twenty years ago, perforated cover plates began to replace lacing bars and stay plates as the connecting elements between the two webs of truss members. The consequent advantages were the availability of the plate section beyond the handhole width as effective section in the design of the member, and the greater accessibility into the interior of the member for riveting and painting. The next step would be elimination of these handholes in the body of the member between joints, and the sealing of the ends of members against the entrance of moisture. Considerable research has been carried on in Germany recently to determine the corrosion resistance of completely closed box members, and several bridges having such members have been built. The enhanced resistance to corrosion of the low-alloy steels may lead to the future use of such members in bridges in this country.

Two bridges using special steels

Two examples of bridges using special steels, both designed by Howard, Needles, Tammen & Bergendoff, are the Mississippi River Bridge at Rock Island, Ill., and the Missouri River Bridge at the Paseo, Kanasa City, Mo.

The Mississippi River Bridge at Rock Island is a four-lane highway structure completed in 1940. The main river bridge consists of five tied arches, two 540-ft spans and three 395-ft spans. Silicon steel was used for the box-girder arch ribs and horizontal ties, and carbon steel for the floor system, bracing, and hangers. The amounts of steel in these spans are carbon steel, 4,160 tons; silicon steel, 3,480 tons; and cast steel, 230 tons. If the arch ribs and ties had been designed in carbon steel, an estimated additional 1,200 tons would have been required.

The Missouri River Bridge is a four-lane highway structure which was completed in 1954. The main river bridge is a self-anchored suspension span with a main span of 616 ft and side spans of 308 ft. In the original design, silicon steel was used for the towers and stiffening girders and carbon steel for the floor and lateral systems. The estimated quantities were: silicon steel 2,550 tons; carbon steel, 2,100 tons; cast steel, 160 tons; suspension cables, including sockets and fillers, 318 tons; and suspender ropes, 31 tons. An alternate design (that finally chosen) used low-alloy steel for the towers and stiffening girders, resulting in a saving of 200 tons in the weight of these items and a minor reduction in the cable quantities. The successful bidder quoted practically the same sum for the two designs by increasing the pound price of the low-alloy steel almost 3 cents above that for the silicon steel. Bids were taken in January 1953, when the Korean War had an adverse influence on bid prices. In more normal times there would have been a saving in money as well as weight through the use of the low-alloy steel.

The bridge designer has the task of evaluating the available structural materials in order to arrive at the best and most economical design for a particular bridge. It is certain that low-alloy steel will be used in many future bridges.

Mid-Manhattan's newest skyscraper, SOCONY MOBIL BUILDING, rises at 42nd Street and Lexington Avenue

What's new in this age of skyscrapers

ROBERT K. POSEY, AIA, Skidmore, Owings & Merrill, Architects, New York

JOHN F. HENNESSY, AIEE, Syska & Hennessy, Inc., Mechanical & Electrical Engineers, New York

WALTER H. WEISKOPF, M. ASCE, Weiskopf & Pickworth, Structural Engineers, New York

H. C. TURNER, Jr., President, Turner Construction Co., New York

The skyscraper is a purely American architectural form. The engineering know-how required to build and operate a tower building is as American as corn in Kansas. In function, it is a beehive of activity—a vertical extension of the busy life of the streets. In structure, it is born of new skills of American industry—a symbol of the exciting technological advances of our industrial age. Its size and soaring height demand an architectural treatment characterized by boldness and intelligence. Hoist towers, cranes, conveyors, steel scaffolding and rigging ingenuity are accepted parts of our work-a-day world. Efficient

planning and use of materials are indispensable criteria in designing a skyscraper, and efficiency is an inseparable part of our business day.

High-speed elevators and moving stairs, affording the vertical transportation without which the building would be very limited in use, are results of American research. Overall luminous ceilings, eliminating glare from contrasting dark ceilings and bright lighting sources, and draftless air-conditioning are a part of the industry's answer to our demand for a better standard of living.

These standards are as different from the office building of twenty-five years ago as power steering is different from the hand cranking that was a feature of the automobile of 1920.

In America, efficient mass production of consumer materials has long since replaced much laborious hand work still prevalent in many parts of the world. The skyscraper is an assembly of factory mass-produced parts shipped to the site and hoisted into place. The lighter the parts the faster the construction schedule, and the lower the manpower consumption on the job.

Corrugated or cellular steel floors laid directly on to structural steel beams, movable interior partitions, flat ceilings of translucent plastic or acoustic tile with recessed fluorescent lighting, and thin exterior skins are prefabrications now in everyday use in tall building construction. The skins or curtain walls employ architectural metals, porcelain-covered steel, and heat-absorbing glass in varied patterns to form shafts of striking appearance.

The entire building now depends so much on uninterrupted electric power for such indispensables as heat, light, vertical transportation, and air conditioning that operable windows may be omitted. A sealed skin formed by a simple sheet of glass set into a metal frame with no moving parts can be designed to be less expensive than windows with their reinforced frames, weather stripping and hardware. This potential saving is projected into the initial and operational cost of heating and cooling plants on account of the absence of air seepage formerly associated with windowed façades.

The skin assembly is at present taking two main, and divergent, directions. In one approach, the designer deliberately deforms thin sheets, the result being a coffered stainless steel or aluminum outer surface, as first developed for the Alcoa Building in Pittsburgh. While not a complete curtain wall—it requires a backing of masonry or concrete—it wins the enclosing-time race hands down. When the steel frame is complete, the prefabricated enclosing skin arrives on the job and is raised into place within a few days. The rest of the job then proceeds with less temporary protection and without delay from rain, sleet or snow.

The other strong contender is a curtain-wall system of individual panels arranged in patterns suggesting the steel skeleton itself. Jointing is accomplished by means of concealed neoprene gaskets and exposed architectural metal sections of highly polished sheen. Glass is the leader in brilliance and beauty for the panel material. Its reflective quality and easily cleaned surface contrast sharply with the drab, sooty, and heavy walls of a previous generation.

Porcelain-surfaced steel is currently the preferred material in this field. When made into panels, it retains many of the qualities of glass. The colors are brilliant and, if the porcelain coating is thick, it has a good depth of texture. A new laminated sandwich technique borrowed from the aeroplane manufacturers has enabled this industry to conquer its old enemy of lack of flatness, which gave the material a cheap look. Flatness now can be assured within a limited range of sizes, and this material, unless it falls into greedy misuse, has a bright future. In the best instances these panels form both the interior and exterior of the skin. In addition, they are thermally insulated to provide a U factor of 0.15.

Steel frame remains the same

Through all this change, the frame for our taller buildings rigidly has remained a steel grid. But this skeleton is a growing thing and is subject to evolution. Because of the trend toward use of lightweight materials, the ratio of dead load to live load is becoming less, and coupled with the possible absence of concrete slab and beam encasement, the deflections due to live load are greater. As a result there is likely to be some harmless but annoying oscillation of the framing.

To design a structure so that the oscillation will not be apparent is a new structural problem, and one on which further questions arise. In the first place, what live load should be assumed? Obviously not the design live load, which is safe but quite unrealistic for a dynamic analysis. Second, what is the period if the live load is assumed to be periodic, or if not, what is the relation of live load to time? Third, what period and amplitude of a beam oscillation would be noticeable or objectionable to a person standing on it? No categorical answers to these questions can be given but considerable progress has been made in determining in the early stages what framing systems would be better from the standpoint of objectionable oscillation. Deflection from wind is also increased by decreasing the dead loads and omitting the concrete beam and column encasement. Again the problem is not one of strength but of designing so that wind deflections cannot be felt by the occupants.

The space above the ceiling and under the floor is extremely "busy." Pressure for economy dictates holding this space to a minimum; yet in it must be placed the structural system, horizontal air ducts, electrical distribution system, lighting system, and sometimes a sprinkler system. Of these the structural framing and the air ducts are the greatest in volume, and an important aspect of the design is to fit the beams and the ducts so that neither is severely penalized and the total space occupied is a minimum.

One solution is to locate the duct system below the beams and girders. This is simple and direct but sometimes causes loss of space since one tight crossing of a large duct under a deep girder may set the dimensions for the entire floor. Where the spans are long and the girders deep, ducts can be placed through holes. This is very economical of space and does not greatly increase the structural cost, but is difficult to administer from the drawing viewpoint, since often the plans for the mechanical work are not sufficiently advanced to determine the size and location of the holes when the steel has to be ordered.

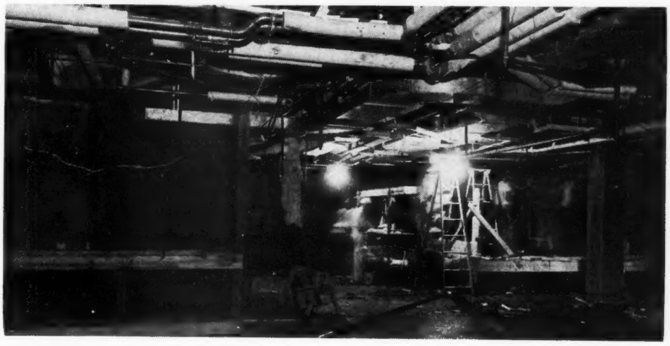
In the case of wind girders, an advantageous solution is to use shallow beams with stubs at the ends. This furnishes greater depth at the ends where the moments are large. Since the moment diagram drops off sharply, the stubs are short and there is a long center section of shallow beam where the ducts can be placed.

In structural steel, a development of great promise is the alloy-steel, high-strength bolt. It is furnished with hardened steel washers, and the nut is tightened with a calibrated impact wrench so as to put a very high tension in the bolt shaft. The steel members are thus tightly clamped together. In fact, the friction between the steel contact surfaces is an important strength factor. High-strength bolts are at least the equivalent of rivets of the same diameter in strength and are superior in their resistance to repeated loads.

While there has been no change to date in specifications or in design procedures, a great deal of research is in progress regarding the underlying theory of the safety factor. The classical concept was based on the load causing the most highly stressed fiber to reach the elastic limit, and the analysis was based on the theory of elasticity. It is

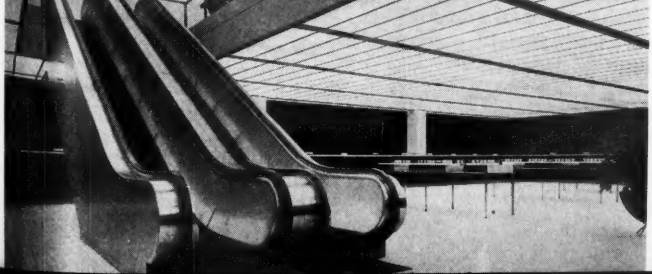
UN BUILDING on East River, New York, has east and west facades composed of unbroken expanse of windows in one plane. Each 4 × 12-ft grid consists of a fixed glazed spandrel and a double-hung window. Note Chrysler Building at far right. For UN Building, Wallace K. Harrison was Director of Planning; Max Abramovitz, Deputy Director of Planning; Edwards & Hjorth, structural engineers; Syska & Hennessy, mechanical engineers. Building was the joint endeavor of four companies operating as Fuller-Turner-Walsh-Slattery, Inc.

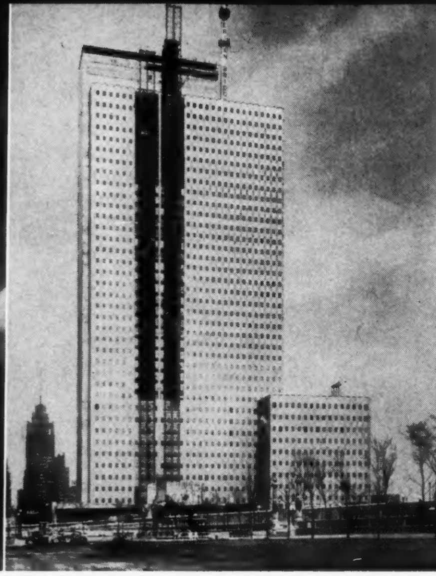
SOCONY MOBIL BUILDING will be enclosed by 7,000 stainless-steel skin panels weighing 100 lb. each. Here a preformed panel has been removed from its cardboard envelop and is ready to be lifted and fastened to subframing. Completion is slated for 1956. Architect-engineers are Harrison & Abramovitz; structural engineers, Edwards & Hjorth; mechanical engineers, Jaros, Baum & Bolles; and builder, Turner Construction Co.

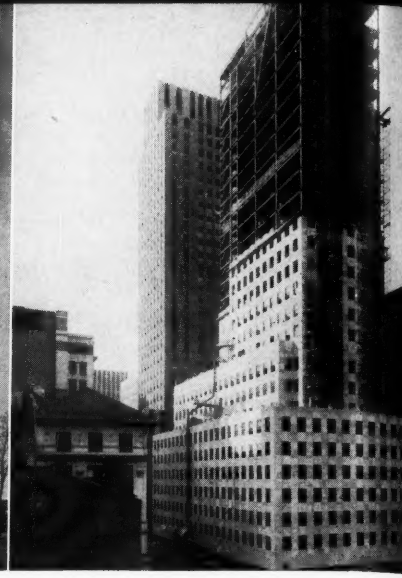


This complex maze of piping, conduits and ducts, to be hidden by a suspended ceiling, is typical of today's office buildings. Ford Motor Company's CENTRAL STAFF OFFICE, Dearborn, Mich., is pictured. Architect-engineers were Skidmore, Owings & Merrill; structural engineers, Weiskopf & Pickworth; mechanical engineers, Jaros, Baum & Bolles; foundation engineers, Proctor, Freeman, Meuser & Rutledge; and builder, Bryant & Detweiler.

Up-to-date interiors feature luminous ceilings and moving stairways, as seen in ultra modern interior of MANUFACTURERS TRUST BUILDING, Fifth Avenue, New York, below. Architect-engineers were Skidmore, Owings & Merrill; structural engineers, Weiskopf & Pickworth; mechanical engineers, Syska & Hennessy, Inc.; and builder, George A. Fuller Co. In view at right, largest structure in Denver's MILE HIGH CENTER is shown. This 23-story office building has unique facade, with one-story-high aluminum frames bolted to building frame. Co-developers of Center are George A. Fuller Co. and Webb & Knapp, Inc.; with Webb & Knapp, Inc., and I. N. Pei, architects; Severud, Elstad & Krueger, structural engineers; Jaros, Baum & Bolles, mechanical engineers; and George A. Fuller Co., builder.







LEVER HOUSE, Park Avenue, New York, was one of first buildings to employ a sealed skin. This glass and stainless-steel exterior surface (above, left) exemplifies the appearance of many of today's skyscrapers. Architect-engineers were Skidmore, Owings & Merrill; structural engineers, Weiskopf & Pickworth; mechanical engineers, Jaros, Baum & Bolles; and builder, George A. Fuller Co. Center view above shows CHICAGO'S TALLEST SKYSCRAPER, built over Illinois Central Railroad tracks on lake front. It has height of 601 ft (41 stories) and contains about a million square feet of rentable office space. Full air conditioning is provided. This Mid-America Home Office of Prudential Insurance Co. of America was designed by Naess & Murphy, architect-engineers, with George A. Fuller Co., builder. SINCLAIR OIL BUILDING at 600 Fifth Ave., New York (next photo), was named for its principal tenant. Completed in mid 1951, building has Robertson Q-floor construction, absorptive-type air conditioning system, and limestone facing to conform with adjacent Rockefeller Center development. Time and Life Building is just behind it at left. For Sinclair Oil Building, architects were Carson & Lundin; structural engineers, Edwards & Hjorth; mechanical engineers, Jaros, Baum & Bolles; and builder, Turner Construction Co.

recognized that in many instances, particularly in the statically indeterminate structure, this concept does not furnish a balanced design. A more modern procedure is to base the safety factor on the ultimate load the structure can support.

Some mention should be made of the use of a concrete frame for taller buildings. A great disadvantage is that the size of the columns becomes so great as to appreciably reduce the usable space in the lower floors. Perhaps rolled steel shapes used as cores in columns will allow more consideration of concrete as the main structural material.

Transportation, power and light

In the modern skyscraper, efficient transportation of both people and material is most important. Substantial advances have been made in vertical transportation. Elevator manufacturers have developed an electronically programmed and operated system which functions without attendants. In addition to the saving in the cost of operation, the elimination of operators provides faster and more complete elevator service. The development of these operatorless cars has been accompanied by a number of other improvements in door operation and signaling which contribute to overall efficiency.

Where a large number of people are to be transported, moving stairs are the most efficient means of transportation. Like operatorless elevators, they do not have to be attended. Office buildings are being built with escalators for the lower floors, usually where these floors are occupied by a single organization. Their speed of operation has been increased 25 percent in the past two years.

Mail conveyors, dumbwaiters, and large pneumatic tube systems have now been developed to an advanced degree and are coming into everyday use where a tenant's administrative work is heavy. The current types are the continuous-chain mail conveyor, the automatic dumbwaiter, and the large 3 × 7-in. pneumatic tubes which are indexed for semi-automatic operation.

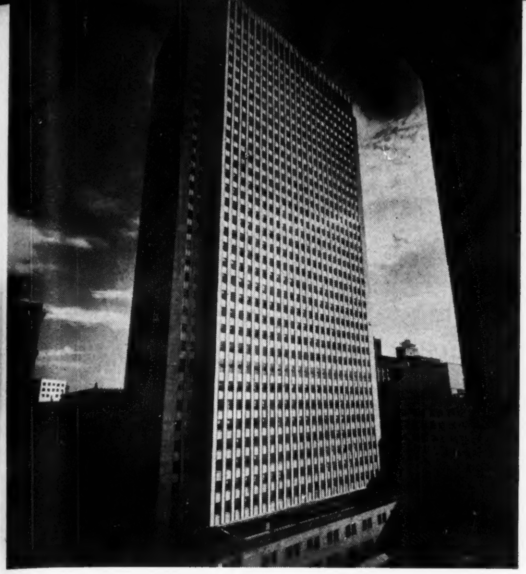
Electrical power requirements have been constantly increasing because of the demand for higher light intensities and the increase in use of office or business machines. To provide for adequate distribution of this power and to give the owner the greatest flexibility, a distribution system under the floor is being employed almost universally. This under-floor system may be either a duct installed in the floor fill or a cellular steel subfloor which provides space in the floor for the electric lines. This duct or cellular system is also used for telephone and other communication lines. The increased load has made it advantageous in many cases to use a distribution system of 277/480 v current rather than the normal 120/208 v. The possible savings with such a system are worth careful consideration.

The trend in lighting has been not only toward higher intensities but toward better quality, such as lower brightness, more even distribution, and less glare. The fluorescent lamp has except for specialized cases, replaced the incandescent lamp almost universally in new office buildings. The development of area lighting and better diffusing media has done a great deal to increase both efficiency and quality of light.

Air conditioning, frequent requirement

Cooling during summer has become a service which must be available in the building just as heating must be provided during winter. Air conditioning no longer need be "sold" to the owner.

This new demand for air conditioning coupled with increased construction costs, has led to decreased story heights and smaller, more efficient, units to lessen loss of rentable space for the housing of air conditioning equipment. The result has been the development of apparatus and applications considered to be theoretical a few years ago. Air velocities of 4,000 fpm in the distribution ducts, making for reduced cross-sectional area, are usual, compared with 1,500 and 1,800 fpm a few years



In Pittsburgh's "Golden Triangle," at 525 WILLIAM PENN PLACE, new 42-story home of U.S. Steel Co. and Mellon National Bank and Trust Co. is completely modern in design. Facing consists of stainless steel fins and Indiana limestone pilasters which extend from sidewalk to roof. Main lobby features steel paneling. Structure was built for John W. Galbraith & Co. Architects were Wallace K. Harrison, Max Abramovitz and W. Y. Cocker; structural engineers, Edwards & Hjorth; mechanical engineers, Meyer, Strong & Jones; foundation engineers, Moran, Proctor, Freeman & Mueser; and builder, Turner Construction Co.

ago. Investigations are being made of the economic possibility of employing velocities in excess of 4,000 fpm.

In order to reduce the work of the air distribution ducts, combination cooling and heating units, replacing the conventional radiators, have been developed. These units handle the "perimeter" load of the building, which is that area extending from the exterior walls approximately 15 ft inward. Window units are available competitively of either the air-induction type or the motor-driven centrifugal-fan type. Primary air for units of the air-induction type, and ventilation air for units of the motor-driven fan type, is usually distributed at relatively high velocities through vertical ducts located at the exterior building columns. Heating and cooling are obtained from water coils which are an integral part of the units, and which are supplied with chilled or warm water from risers adjacent to the exterior building columns. An alternate window-unit type is the dual-duct unit to which cooled or warmed air is supplied from high-velocity air risers replacing the primary air and water risers.

To further decrease the space occupied by air distribution ducts, "radiant" ceiling panels for either cooling or heating, or both, are available. An insulated metal pan (similar to the acoustic ceiling pan) is attached to suspended pipes which serve as supports for the panel and at the same time distribute chilled or warmed water. In this case the distributing ducts supply only the amount of air necessary for ventilation and dehumidification.

"Radiant" floor cooling and heating are also being developed. The aim is to reduce the space occupied by air ducts by distributing the cooled and dehumidified or heated air through cellular steel subfloors.

To compensate automatically for load variations during occupancy due to sun, lighting and occupants, a dual-duct system has been developed in which two air-distribution ducts are provided, one handling cold air and the other warm air, the ducts being brought together and the air automatically mixed before being supplied to the space. Air in the ducts is distributed at high velocities.

Steam-operated refrigeration units in combinations and in conjunction with electric power-driven apparatus, are being used to reduce energy consumption and cooling-tower make-up water costs. Reduced operating noise levels are being striven for constantly.

Electronically operated automatic temperature controls which respond almost instantly to temperature changes and which appear to reduce maintenance costs, are available at a relatively small initial cost increase over pneumatically or electrically operated units.

Remote temperature indicating and operating equipment is available for centralized control and operation of equipment to insure comfortable conditions within the air-conditioned spaces at all times.

Improved construction methods

To the layman, it may appear that there has been relatively little improvement in actual construction procedures. Nevertheless methods and equipment have been steadily improved and the total picture is one of radical change.

In the field of materials handling there are improved hoists, cranes, excavation equipment and other powered machinery. The use of lift trucks and the handling of many types of materials on pallets is now widespread. Today, brick and masonry block may be palletized at the factory and transported in that form by all handlers until it arrives at the building site.

Much labor formerly performed at the site is now done in shops. For instance, pipe work, duct work, whole wall panels, partition sections, and such are now delivered to the job in large units, ready for erection, a procedure which substantially reduces the amount of job fabrication with resulting savings in time and cost. Better and more efficient tools have been developed for the assembly of these many materials and products.

There has been a steady improvement in safety methods and precautions, and the frequency of accidents has been substantially reduced. Safety programs are dictated not only by humane considerations but also by hard-headed business motives. Every lost-time accident is a costly matter, and insurance costs on construction today have become a major item.

The task of organizing for the construction operation is challenging and involves problems of logistics. Considerations of economy and time, which are so important to an owner—whether he is building for his own use or for speculation—make it highly desirable to have a team-work relationship at an early date between owner, architect, engineer, and builder. When all work together and plan every aspect of the building and its construction, the specialized knowledge of the architect and engineer is coordinated with the builder's knowledge of methods and products, purchasing and construction costs, to best meet the owner's needs and to fit his financial frame-work.

The start of erection signals the beginning of the second half of the game, and the modern builder is the quarterback. He interrelates the efforts of the many subcontractors and the trades in

(*Continued on page 156*)

Economics and esthetics —

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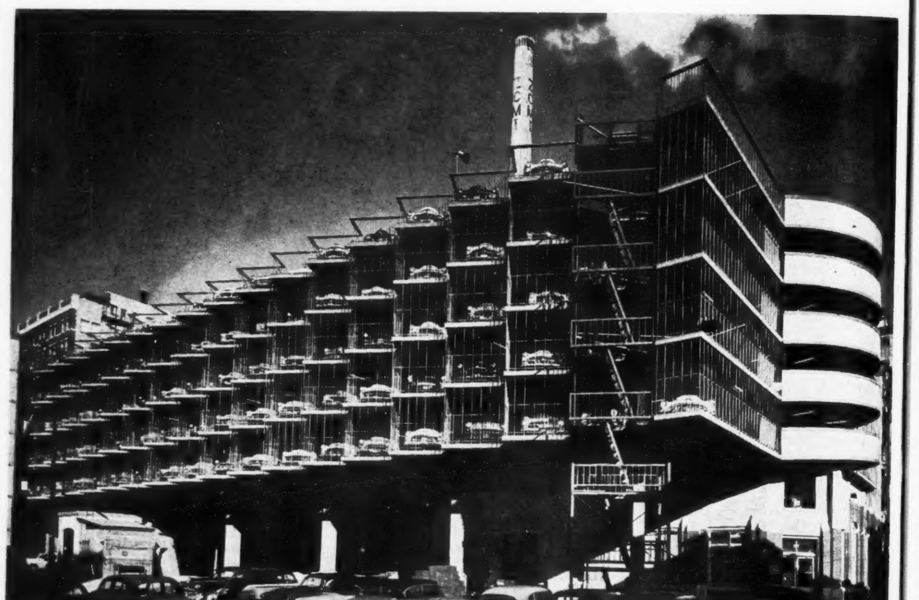

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(1) Shell structure for Moore Equipment Co. of Denver uses folded plates of Z and V shapes, designed as ordinary concrete slabs in short direction and as girders joined at their edges in long direction. Architect is Tom Moore; structural engineers, Ketchum & Konkel; and contractor, N. G. Perry Construction Co., all of Denver. Photo Winter Prather, Denver.

(2) Flat-plate floors for parking garage of Zion Cooperative Mercantile Inst. in Salt Lake City were constructed from top down. Columns were precast and prestressed. Forms were constructed on top floor and lowered by cables. Slabs of variable thickness were analyzed by photoreflective method of Presan Corp. of Los Angeles. Engineers were Bowen, Rule & Bowen of Los Angeles; contractor, Jacobsen Construction Co. of Salt Lake City.

—new building structures serve both

MILO S. KETCHUM, M. ASCE

Ketchum & Konkel, Consulting Engineers, Denver, Colo.

In the past twenty-five years, the structural engineer can point to a number of new types of structures in this country which have been accepted as useful structural systems. Their development has been spurred on by the necessity of reducing costs either by adopting labor-saving and mass-production methods, by reducing the amount of materials required, or by extending the performance of existing materials beyond their previous ability. Even though the reason for the development has been economic, the new methods have resulted in structures with greater esthetic and architectural appeal. Some have been developed in this country; others, originated abroad, have been adapted to construction in this country.

With the development of the moment distribution method of Hardy Cross, Hon. M. ASCE, and the model analysis of the Presan method, the American engineer has made enormous strides in analysis. General knowledge among structural engineers of the techniques of analysis of shell construction has perhaps lagged behind the use of shell structures. However, American engineers are quick to learn a new method if they can see its advantages.

The accompanying photographs illustrate some of the typical new developments, most of which are familar to structural engineers. These photographs have been obtained from the architect or engineer or contractor involved and their assistance is gratefully acknowledged.

Three main aims

Instead of describing in detail here the analysis, design and construction of these buildings, it is of interest to consider the aims that prompted their development. These aims may have been economic, esthetic, or technical, singly or in combination, and may have originated with the architect, the engineer, or the contractor, each of which has contributed to this development.

The economic motive has stemmed from a desire to produce structures of lowest cost and maximum utility. How can the instruments of mass production and labor-saving machinery be adapted to construction? This motivation has led to the development of precasting of concrete structural members, including prestressed construction, and the use of Lift Slabs and tilt-up walls. In these methods, the construction may be performed in the shop with multiple use of formwork and controlled conditions. Lifting into place is accomplished by cranes or hydraulic jacks, and every effort is made to reduce the cost of labor and formwork.

It is interesting that these structural systems also satisfy the esthetic requirements of architecture, which lays emphasis on the expression of the structure as part of the decoration. Prestressing permits thinner structural

(3) Arches in plane of gabled roof frame school gymnasium in San Mateo, Calif., in place of usual steel rigid frames. Rafters of 40-ft span carry vertical loads. Action of structure is similar to that of a concrete folded plate. Designer was Alexander G. Tarics, engineering partner of architect-engineer firm of John Lloyd Reid & Partners of San Francisco, Calif. Photo by Phil Fein, San Francisco.

(4) Lift Slab method was used for series of apartment buildings in Calgary, Alberta, Canada. Two buildings have six floors and roof with plan area of 156 × 63 ft. Roof slab was raised height of 69 ft. Each floor was cast in two sections, maximum number of columns in one lift being 18. Architect was Peter Caspari of Calgary and Toronto, and structural engineer, W. V. Zinn & Associates, Ltd., of Toronto.

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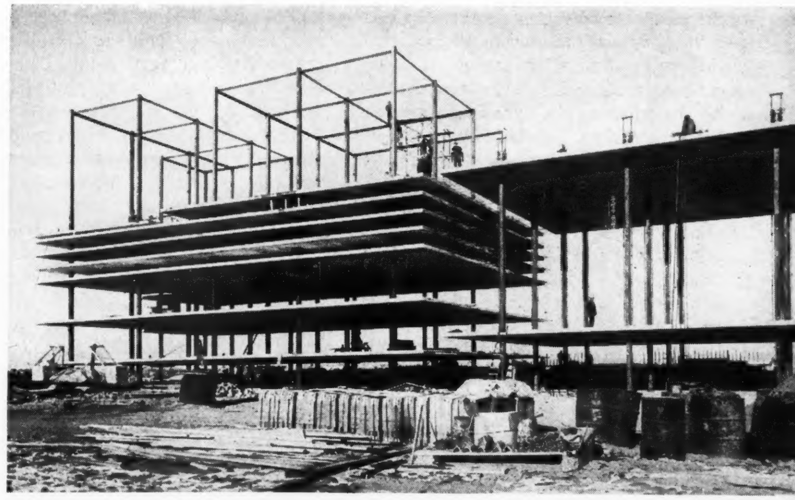


Wood is an ideal structural material—light, strong, and easily worked. Its chief drawback, short lengths, is overcome by use of glued and laminated timber, here used for troop and aircraft supply warehouse at Wichita Air Force Base. Typical bent has spans of 63, 72 and 63 ft. Architects are Schmitt, McVay & Pedie, Wichita, Kans., and fabrication was by Timber Structures, Inc.

members. Lift Slab construction lends itself to long cantilever overhangs and large window areas provided by the flat-plate structure. The real basis of the economy of modern structures is in the acceptance of the structure as a part of the finish. In this regard the general public has had to be educated to consider concrete and bare steel as finish materials. In house construction this concept is now being accepted by the home buyer because he realizes that it enables his dollar to buy more area and more appliances than the usual materials.

Economy may, in many cases, be the motive for utilizing shell structures. A minimum of materials is necessary because structural members are in direct compression or tension rather than bending. The greatest saving in cost, however, results from the use of formwork constructed so that it can be used many times. The argument against the adoption of shell structures in this country is that labor costs are high and the saving in materials may not be offset by construction economy. American engineers also are not familiar with the design of shells. The publication of Manual No. 31 of the ASCE on "Design of Cylindrical Concrete Shell Roofs," has done a great deal to dispel the mystery surrounding barrel shells. However, there is much still to be accomplished in this regard. Shells are no more complicated than other types of members. The difficulty is that many of the concepts are unfamiliar.

Architects also must have a part in the development of shells. They appeal esthetically to the architect because the forms are new and exciting. Many different shapes of shell structures are possible and monotony can be avoided.

Material performance extended

Some of the new structures result from extending the performance of older materials beyond their previous ability. Prestressed concrete is an example. By using high-strength wire or cable reinforcing, which is stressed by hydraulic jacks either before or after the concrete is cast, it is possible to reduce the amount of materials required for a given span, and to construct spans of great size because of the reduction of dead load. Members may be fabricated as individual blocks and strung together by prestressing, as illustrated by the accompanying photograph of a structure built by Ross H. Bryan, M. ASCE.

Laminated timber is also in this category. Dimension lumber such as 2 × 4's and 2 × 6's are glued together in timbers of any length or size. Curved or tapered members may be built. The highest grades of material can be used in the outer laminations of beams, and less expensive grades at the center where the stress requirements are not so great. There are a large number of fabricating plants now available for laminated timber construction.

Progress also has been made in steel construction. Space structures may be used in steel, as indicated by the gymnasium built at San Mateo, Calif. and shown in a photograph. Also, there is now considerable interest in the design of rigid-frame structures by limit design, or ultimate design. This development will probably not lead to new types of structures but will provide more economical solutions to present forms. Again this is a case of extending the properties of present materials.

The role of the trade associations should be acknowledged. They have done much to educate the architects, engineers, and contractors. Among these are the American Institute of Steel Construction, the Portland Cement Association, and the newly formed American Institute of Timber Construction.

New methods of analysis

Along with new structural forms, there has been a development in methods of analysis which has permitted a much more careful and rapid design of framed structures and other structural forms developed before 1930. It is interesting to note that the first issue of CIVIL ENGINEERING and the publication of Hardy Cross's famous paper on the moment distribution method in the ASCE *Proceedings*, date from the same year, 1930. (However the *Transactions* publication date was 1932, Vol. 96, p. 1.) The contributions of Professor Cross are too well known to be described here and are well documented in the literature. His methods have been universally adopted in this country as well as abroad and have done much to stimulate the development of building structures.

Experimental methods have been developed and put into extensive use for determining stresses and reinforcing in flat-slab construction. The Presan analysis, developed by the firm of Bowen, Rule & Bowen of Los Angeles, uses a photoreflective model and accurately predicts the distribution of stresses and the proper arrangement of reinforcing. The lack of intensive mathematical training has given the American engineer a certain sense of inferiority as compared with the European engineer, particularly in the fields covered by the theory of elasticity. A wider knowledge of finite difference methods, by which almost any differential equation can be reduced for solution by simultaneous equations, may do much to close this gap.

Some of the developments mentioned have started in this country and others have permeated from abroad. The Lift Slab and the tilt-up wall are peculiarly American developments, but pre-

Coliseum at Charlotte, N. C., civic center has span at tension ring, at top of columns, of 332 ft and rise above ring of 60 ft. Precast columns lean outward. Architects were A. G. Odell, Jr., and Associates, and structural engineers, Severud, Elstad, Krueger of New York, N. Y. Photo by Joseph W. Molitor, Ossining, N. Y.

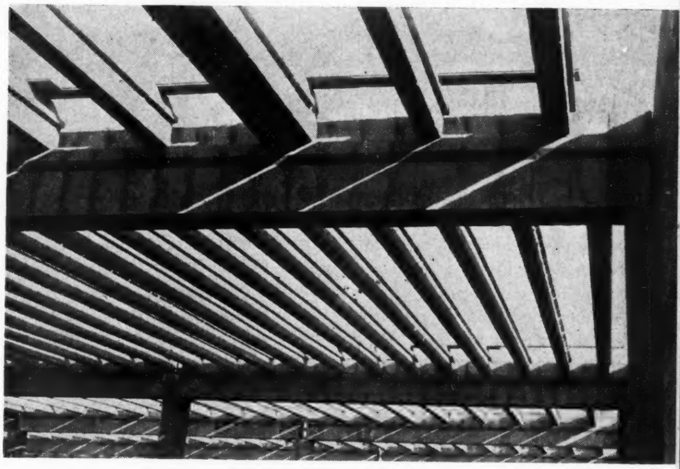
stressed concrete and shell structures were widely used abroad before being introduced into this country, and their development here has lagged behind European progress.

What can the structural engineer do to keep in the forefront of developments? The engineer, being only a part of the architect-engineer-contractor team, has only partial responsibility. In most cases it is the architect who must make the final decisions, based on the contractor's estimates of cost, his faith in the structural engineer, and his willingness to take a chance with new construction methods.

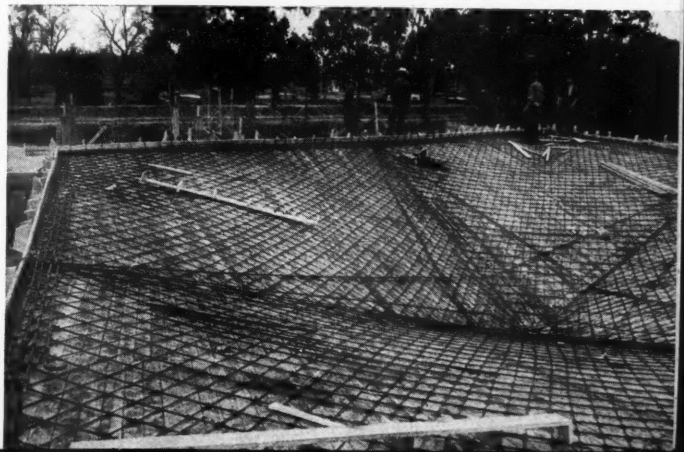
First the structural engineer must become aware of new developments. must learn how to design the new structures, know the costs of construction and be aware of the esthetic problems of the architect. Then he must suggest structures to the architect, talk with the contractor about them and find their advantages and disadvantages. When the time comes to use the structure, then the entire team will be ready. Every self-respecting structural engineer should have these new structures in his bag of tricks to be produced at the right moment and for the right conditions.

The past twenty-five years may be looked upon as a period of considerable development in the structure of buildings. As a result of the combined efforts of the engineer, the architect, and the contractor, new forms and new methods of construction have been developed. The basic structure is being used as a dominant architectural element and as a finish material. Space construction is beginning to be understood and to be used for thin-shell concrete structures and steel frames. New materials have been developed. The architect, engineer, and contractor are beginning to solve the problem of the adaptation of methods of mass production through the use of precast and prestressed structures, Lift Slabs, and tilt-up walls. The engineer must continue to educate the architect in the use of new types of structures. We are really on the brink of a new era in structures which will be much more exciting to the architect, the engineer, and the contractor. It will be interesting to see the progress of the next twenty-five years.

System of precast concrete blocks prestressed by steel-wire strands has been developed by Ross H. Bryan, M. ASCE, consulting engineer of Nashville, Tenn. Here prestressed block girders spanning 30 ft support prestressed block joists of 26-ft span. Both are made continuous over supports under live load by means of mild steel reinforcing bars in topping slab. See Mr. Bryan's article in *Eng. News-Record,* Apr. 22, 1954.



"Umbrella" shell structure that is about the ultimate in lightness (1.5 in. thick) has been developed by Felix Candela, architect of Mexico City. Each umbrella is composed of four surfaces called hyperbolic paraboloids, and is drained to center column through pipe leading to storm sewer. Footings are also hyperbolic paraboloids, 6 in. thick, resting on soft clay. See articles by Mr. Candela in *Consulting Engineer*, May 1955, and *Journal of ACI,* Jan. 1955, Vol. 26.



A forward look

WALTER L. COUSE, M. ASCE

During the past twenty years, construction of buildings in the United States has taken tremendous strides forward in speed of completion, quality of workmanship and materials, and efficiency of operation.

In earlier days, homes and buildings for trade uses were constructed with the loving attention and workmanship of the man or family that was to occupy the structure. The prospective users hewed the trees into timbers and made the brick and other masonry materials with their own hands from the clays available nearby. Of necessity the materials were local. Excavation was accomplished by pick, shovel, and wheelbarrow—or by horse and scraper. Hoisting or towing was done by means of a rope pulled by a horse or mule. I saw these methods being used in a populous area as late as 1933.

The impact of the 1930–1940 depression, and the need of industry to rebuild and revitalize the economy, led to intensive studies of ways of placing consumer and capital goods on the market at lower cost to attract buyers. The further impact of World War II brought the demand for a speedup and mechanization of all methods of construction. These two important influences—the depression and World War II—completely revolutionized the design, construction methods, materials, and equipment used in constructing industrial plants and public buildings.

During the depression the basic design of buildings, the materials used, their arrangement and structural assembly did not change materially from that of the previous twenty-five years. Then, with the war, came the demand to "get production at once and at any cost"—and do it with restrictions on the amounts and types of materials and equipment used.

This demand for speed and efficiency, together with a general scarcity of materials, provided the incentive to develop new and more efficient industrial-plant layouts, and lighter, more airy and more stream-lined office structures. It produced an open-minded attitude toward new designs and materials which perhaps otherwise never would have developed. Because of this open-minded attitude on the part of most architects and engineers, building construction has been going through a revolutionary process that will benefit all mankind. With the peace, this same search for streamlined results appears in our schools and public construction, our churches, stores and places of business, and even in our homes.

Mechanized jobs

In examining the effects of this construction revolution on the various parts of buildings, let us start our analysis with the foundations and work our way up to the roof.

The old horse-and-drag methods of excavation changed dramatically to the steam shovel, riding first on iron wheels and later on crawler-type treads. Then horse-drawn dump wagons were used to carry the dirt. Later hard-rubber-tired dump trucks were substituted, requiring vast quantities of maple hearts for plank roadways. Still later, pneumatic-tired trucks eliminated the plank roadways and the countless delays caused by soft ground. The modern diesel-powered backhoe and dragline have gone far in speeding up the work and alleviating the problems of equipment working in soft earth below the ground level. Outside of congested sections, where a building covers a large area, Tournapulls, scrapers, end-loaders and bulldozers move great quantities of earth in fractions of the time previously required, and at greatly reduced costs.

In the Detroit area, around 1925, large excavations were costing 95 cents to $1.05 per cu yd. Today, such excavations are being made with modern scraper equipment, in spite of higher wage scales, for 30 to 35 cents per cu yd—with a profit to the contractor. For confined areas, for underpinning, press pits and shallow wall foundations, the small farm tractor with backhoe attachment, with a capacity of 5 cu ft and larger, is valuable. Such converted tractors can also be used as light bulldozers and scrapers, and to haul trailers of material around the job site. A new unit just out will cut trenches for shallow wall footings $2^1/_2$ to 5 in. wide and 40 in. deep at a speed of 125 fpm in average soil. All these machines are invaluable for constructing industrial plants.

For backfilling in the open, and in clay soils, the sheepsfoot roller has been a mainstay for years. It still is,

For excavating large quantities of material, diesel-operated backhoe, loading rubber-tired truck, is economical.

at building construction

Walter L. Couse & Company, Engineers and Contractors, Detroit, Mich.

but there has also been added the rubber-tired roller, the compactor based on the interrupted-pressure principle, and a unit known as the Jackson multiple compactor for subbase compaction, all giving excellent results. Wherever compaction is required in confined areas, around foundations and over pipes, compressed-air tampers and self-contained portable hammers opperated by one man are both efficient and practical. They give much better results than the old-fashioned water inundation method, which produced settlement but not compaction.

For mixing concrete and pouring it in foundations and walls to ground level, greatly improved machines are available, such as ready-mix trucks and other devices for conveying the premixed aggregates to the site. In earlier days large working areas were required at the site for storage of aggregate and cement. As a result there was great wastage and inadequate controls for mixing. Fifteen years ago ready-mix facilities were available in only a few of the larger cities. Today it is not surprising to find ready-mix available in the smallest communities, giving assurance to the architect, engineer and owner, of properly balanced aggregate, accurate water measurement, and adequate mixing to meet the strength requirements of the work. Transit-mix trucks have capacities up to 13 cu yd each, although the average is about 4 cu yd. They are frequently used for brick mortar where a large amount is required. Another vehicle used where concrete is mixed away from the site is the Dumpcrete truck. These non-agitating trucks are popular in many sections of the country and are very advantageous under certain job conditions. In Europe transit-mix is not common. In six weeks recently spent traveling in Europe, I saw only a few such trucks in London, and none anywhere else.

Formerly the conventional way of moving the mixed concrete to the forms was by hand-pushed wheelbarrows and two-wheeled buggies. These are now being replaced with three-wheeled power buggies and power-driven wheelbarrows. Gravity chutes are being replaced by power-driven belt conveyors, which often carry concrete for great distances. Pouring by Pumpcrete is coming into wider use as the cost of the original equipment and plant-change setups is reduced. Pumpcrete is especially valuable in reaching difficult parts of a job in cases where plant production must be maintained or

Cable-raised dump body on dirt truck (at right) can carry tremendous loads.

Versatile tool for industrial plant construction is small rubber-tired farm tractor on which backhoe and front loader are mounted. John Deere tractor is pictured below, but many manufacturers make this type of unit.

Precast concrete wall slab is set by lift truck in a structure built by Lift Slab method. Note floor collar welded to steel column, top foreground.

Cinder blocks provide effective interior finish for many types of modern buildings, here illustrated by interior view of First Presbyterian Church of Royal Oak, Mich. Architect was Harold E. Wagoner, Philadelphia, Pa.; General Contractor, Walter L. Couse & Co., Detroit, Mich.

traffic continued without interruption. Mass movement of concrete by Pumpcrete through pipe of 7-in. inside diameter is practical on the level up to 1,200 ft from the mixer and vertically to a height of many stories above the ground, all with excellent control of the mixed aggregate.

Truck cranes are useful for placing concrete, particularly because they can be moved to the job on a highway. A crane can come to the job in the morning, make a substantial pour, or perform other duties in elevating, distributing or reaching to distant parts of the job, and then return to its garage for another job the next day, which reduces rental costs chargeable to any individual job. Where continuous crane service is needed, a crawler crane remaining at the site can contribute much to job progress. For a building of many stories, the elevator tower can handle concrete and other materials or equipment needed to great advantage. An additional aid is a "monkey-on-a-stick" boom hoist fastened to an outside corner of the tower. Conveyors of all types and lengths are coming into common use for lifting concrete, sand, mortar, brick, tile, lumber and other items of moderate size and weight to heights up to two or three stories. Conveyors are excellent for projecting through wall and floor openings to aid in clearing out hard-to-reach areas, removing hand-excavated materials and lumber, or for carrying in new materials cleanly and expeditiously.

Precast concrete favored

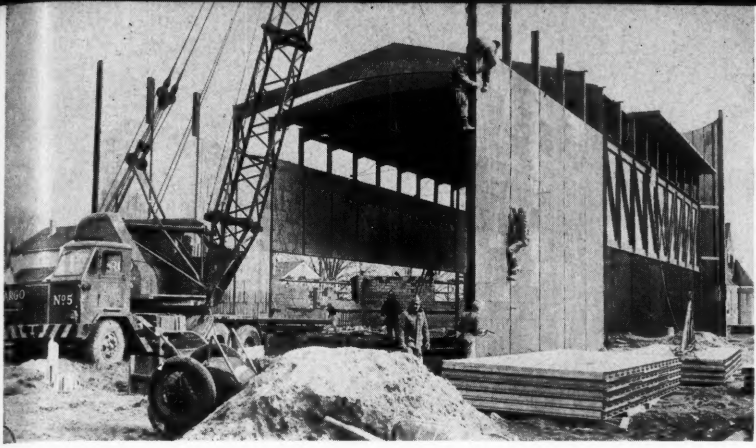
As structural elements of the building, precast concrete units in many forms are coming into use. The future for precast concrete units, and more particularly prestressed units, is unlimited. Already low-slump concrete of 8,000 psi is being specified for precasting work. This summer in Europe I saw factories making precast prestressed beams, girders, and joists on a regular production-line basis; also, all types of slabs for floors and walls, stairways, door frames and windows with glass in place, as well as special items for architectural effects. The results were most satisfactory.

Because of its shortage of steel and excess of cement, Europe has gone farther than we in the United States in the development of factories for producing precast and prestressed structural elements. Sweden, Denmark, The Netherlands and England have outstanding factories which ship precast and prestressed units all over the Continent, to Africa and even to Greenland. One of the largest of these factories is in The Netherlands, where up to 1,000 men are employed, plus a shipping and erection crew of 100 more. This does not include the design engineers or other technical personnel. The manufacture of cement in Europe has developed much faster than our own and her production has increased, reaching 59 million tons in 1953 and 62 million tons in 1954, that is, one-third of the world's production.

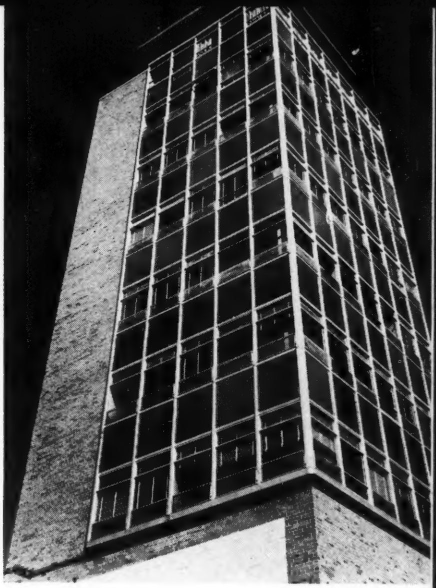
In this country on-the-job precasting is much more common than in Europe. Only a few companies specialize in doing simple precasting work in a "factory plant." This country is still blessed with large open areas around her cities which make on-the-job precasting, with subsequent short hauls, quite practicable. We have not made wide use of precast elements except in simple form, such as wall, floor, and roof panels, sills and lintels, and sewer and water pipe. The last two items are common and widely used. In heavily congested areas, precast elements for buildings are not too much in demand because engineers and architects have not yet prepared many designs utilizing precast elements in sufficient volume to justify their manufacture on a large scale. The use of prestressed beams and girders for bridges, and for the long spans of buildings supporting heavy loads, is advancing more rapidly than their use for the lighter members of buildings. However, we are still far behind the kind of specialist treatment this matter has received abroad. I believe our next step forward in construction techniques will be in this field, and prestressing is the most important phase of such work.

Precast cinder and concrete block are coming into general use. Up to a few years ago, these units were used only for backing up face brick and then were plastered or covered with a finish material. Now the use of exposed cinder block for interior surfaces has materially cut building costs, first in factory buildings, then for the offices connected with those factories, and now for schools, churches, theaters and other public buildings. Excellent results are being obtained. The Detroit area seems to be outstanding in this type of modern construction.

Concrete blocks also have been used in assemblies, between vertical steel channels, to form prestressed wall panels which are delivered to the site and erected as units by cranes. No mortar is needed since all the blocks in each panel are held together by steel rods running through the blocks and tightened by nuts at each end. The steel channels of adjacent panels are welded together so as to form a box column. Fusion-welded girders or trusses are in turn welded to the columns to support similarly assembled concrete-



Preassembled Strestcrete panels, consisting of concrete blocks, assembled and prestressed between structural steel channels, form building walls. After erection, adjacent steel channels are welded together to form box columns which support fusion-welded roof girders. Roof panels, like wall panels, consist of preassembled concrete blocks.



Aluminum-faced sandwich panels 3 in. thick, combined with brick, form walls of control tower for Port Columbus airport. Consulting engineer was J. E. Greiner Company, and architect, James R. Edmunds, both of Baltimore.

block roof panels. Great savings in dollars and time have been realized on industrial buildings and other structures by using this method.

Precast asbestos cement walls and roof sheets, often in corrugated form, are in common use. This material is also made into pipe for conducting water and heat. Production of these items has jumped from around $60 million in 1950 to $90 million in 1955.

Reinforced concrete buildings

The Lift Slab method of building construction has received a lot of attention in this country since 1950. It was started as the "Youtz-Slick Building Method," initiated by the Institute of Inventive Research, of San Antonio, Tex. The technique consists of casting the floor slabs without forms one on top of another, including the roof, much like a stack of pancakes. When raised to final position by hydraulic jacks, each slab is supported by metal collars buried in the concrete at the column points and then welded to the columns. Certain firms are now licensed to use this method. A story by J. P. H. Perry, M. ASCE, on the largest of these installations to date, the Ford Motor Company's Office Building in Dearborn, Mich., appeared in the June 1955 issue of Civil Engineering. Architects and engineers are still divided in their reactions to this method from the cost viewpoint, but it illustrates the advanced thinking of engineers and the owner public. Its use will become more general as our construction thinking advances.

The tube slab, in which paper tubes are inserted to develop a cellular type of floor, saves both weight and concrete over the conventional reinforced slab. Savings of 15 to 20 cents per sq ft have been shown. Tube slabs permit greater ceiling heights because of their shallow depth, thereby allowing a reduction in the overall height of the building. Their use is not practical for all types and designs of buildings.

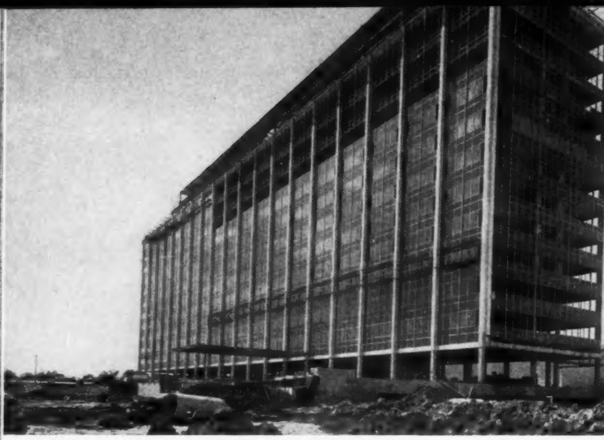
While slip forms have been used for years for the continuous pouring of high circular silos, this type of construction is now spreading to all types of buildings for all uses. Multi-storied buildings of reinforced concrete have become much more common during the past five years. Apartment houses and hotels in Latin America and abroad 30 to 39 stories high, and an office building in Brazil 34 stories high, are the highest of the all-concrete type of structure. The availability of cement, or the lack of structural steel at comparable prices, makes reinforced concrete construction for buildings more desirable in these areas than in the United States. However, Florida and California have some marvelous examples of modern ideas realized in exposed concrete work. In colder sections of the country structural concrete frames are often veneered with brick or stone.

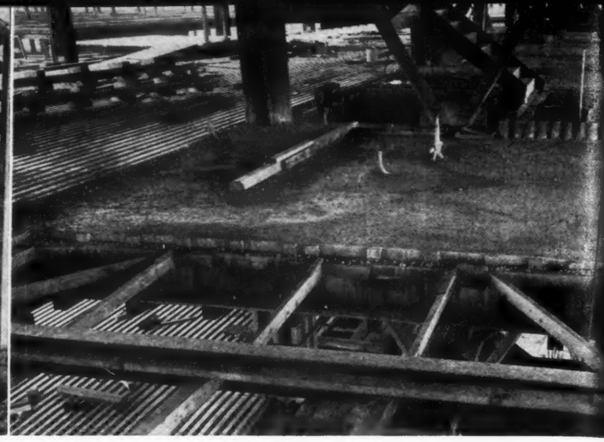
Methods for finishing concrete surfaces have not changed for many years, although power rotary finishers are more common than formerly. Power units for finishing all surfaces are available so that hand rubbing by emery stone is frowned upon even by the labor unions.

Metal framed buildings

Considering further the structural elements of modern buildings as compared with those of yesteryear, we come to the structural steel frame. This has not changed materially except for the use of a higher-strength steel and the development of different sizes and types of steel members. Junior beams are used more, and bar joists are becoming quite common for floors and roofs with moderate loadings. There has been little change in riveting equipment, although riveting is being superseded slowly by welding and high-tension bolts. The latter are being used more frequently in multi-storied buildings, although riveting is still predominant in high structures. For industrial plants and buildings covering a large ground area, with one or possibly two floors, welding or bolting is becoming more and more the accepted treatment. Welding techniques have improved greatly, especially for electric welding. The latter is most common with junior-beam or bar-joist construction, and is very fast and wholly satisfactory.

A common design for one-story industrial structures consists of steel columns and beams on 30 to 50 ft centers, the beams connected by bar joists 12 to 20 in. in depth, depending on floor or roof loads, and placed 7 ft 0 in. or 7 ft 6 in. on centers. Steel decking in lengths of multiples of 7 ft 6 in. (usually 22 ft 6 in. or 30 ft 0 in.) is laid at right angles to the joists and spot welded at each joist contact. For roof work only, this type of deck is frequently changed to gypsum, either poured or in slabs, resting on $1^1/_2$- to 2-in. tee irons running at right angles to the joists and welded to them. For pouring, 1-in. insulation board is laid between the supporting angles of two tee irons, and gypsum is poured over it. This board is painted white or light cream in the factory and therefore does





Exterior skin of Central Staff Office Building for Ford Motor Company in Dearborn, Mich., consists of prefabricated porcelainized steel panels supported on aluminum framework. Robertson "Q-Floor" in same building (view at right), is welded to beams and provides spaces for electrical conduits. Architects are Skidmore, Owings & Merrill; contractor, Bryant & Detweiler.

not need to be field painted, and it serves also as built-in insulation for the roof. This is less costly than the precast concrete roof slab, although it cannot take as much load. Paneled aluminum roof sheets similar to steel decking are also coming into use. The panels are attached directly to the metal framework of the structural joists or beams.

For floor and roof slabs with steel joists, a popular and economical method of construction is to lay expanded metal lath over the joists and then pour $2^1/_2$ in. of concrete, quite dry, on the lath. This makes an excellent lightweight floor. The open web work of the joists makes it easy to run pipe and conduit through them.

Various manufacturers make other types of prefabricated flooring, many of corrugated or bent steel of heavy gage. The corrugations, which are of all shapes and types, increase the rigidity of the decking. Typical is the Robertson "Q-Floor" and the type made by Detroit Steel Products and by R. C. Mahon. All these floorings provide open places for conduits and piping. Concrete $1^1/_2$ to 2 in. thick is poured on top of the sheets to make a floor surface ready for finish treatment. This type of flooring is well adapted to, and quite common in, multi-storied buildings.

Lightweight walls and partitions

After the erection of structural units comes the treatment of the outer walls. Here the most radical changes have taken place in recent years. Time will determine whether the metal skins of today are better than the masonry walls of earlier years, or are sources of new troubles. Metal or preformed exterior wall surfaces are clean, sharp appearing, architecturally attractive, and lend themselves to more rapid handling, as they are fabricated off the site in units ready for erection.

The standard building of the past half century was a semi-rigid frame of a material capable of adjustment to loads and temperature changes. The shell walls were a rigid enclosure of brick, stone and tile with a plastered interior. The frame and enclosure having different coefficients of expansion and contraction, the inevitable result was the development of unsightly wall cracks which caused leakage, and when repaired, tended to recur with every readjustment of the building.

A one-story industrial plant with a structural steel frame, steel roof deck, and steel or aluminum sash walls above low masonry curtain walls unattached to the structural frame, is a structure that can breathe, expand and contract with the materials of which it consists. Troubles with cracking and leakage are nearly eliminated. With the old-type frame of concrete, with steel sash and a masonry enclosure, cracks and leaks are very likely to occur, but earlier thinking was that a factory was a factory and such unsightliness was to be tolerated.

With the construction industry's new attitude, new studies and approaches to attractive as well as stable industrial and public buildings, engineers are working to correct this situation. Their best answer is the metal exterior wall. The materials used for these "skin" surfaces have been many—steel sheets, aluminum, stainless steel, gypsum and other pre-formed materials. They can be shaped, fluted, ribbed, or embossed. But the more shaping required, the greater the expense.

Insulation is frequently provided by spraying lightweight plaster on paper-backed wire mesh fastened to the metal girts of the panels. This is only one of several methods used for insulation. These higher costs of manufacture and assembly, including insulation and methods of anchoring and fastening, are offsetting the cheaper cost of job setting so that as yet there is no overall saving. However, whenever an operation is transferred from on-site hand work to off-site factory and machine production, opportunities are created for lowering costs. The big problem is that each owner is individualistic and wants his building to be different from every other. Too much uniformity in face materials encounters owner resistance. Design and manufacturing ingenuity must also meet and satisfy this human trait of the owner while at the same time producing the prefabricated panels by cost-saving production-line techniques.

Completely movable interior partitions are more and more being made of prefabricated metal with baked enamel finish or plywood with attractive fine-grained wood finish. The big advantage of the prefabricated partition is the ease with which it can be moved from place to place so as to change office layouts at will. Such rearrangement is impractical with plaster and tile construction. The partitions in several thousand square feet of offices have been changed by our firm over a weekend with the result that on Monday morning they looked as if they had always been that way. These movable partitions are universally 2 to $2^1/_2$ in. thick and, being insulated, are soundproof against ordinary office noises.

Heating, cooling, and lighting

With our structure planned and interior partitions determined, we must heat or cool the usable space, light it, and provide such power as may be required. Formerly the only cooling was what an open window could provide, later helped by an electric fan. Now air conditioning for offices, stores, theaters and public places is no longer a luxury. Even certain types of industrial plants are finding air conditioning necessary because the even temperature promotes the accuracy of instruments and at the same time removes dust. The average factory does not as yet enjoy air con-

ditioning, although large fans are generally used to keep air circulating.

For heating, the old-fashioned steam radiator, which collected dust and dirt and did not provide especially good distribution of heat, has been replaced in offices by hot-water fin convector or baseboard radiation and circulating air blown through heating coils. Coils hung from the ceiling, with fans to circulate the hot air, are common in factories. Smaller factories use gas- or oil-fired ceiling-hung coils with fans, plus a small hot-water boiler for baseboard or convector radiation in offices. Individual gas- or oil-fired radiators are available for heating offices and individual window-type conditioning units for cooling them. Radiant heat in concrete floors, and sometimes in ceilings, is frequently used for schools, churches and large areas, but these also require ducts for ventilation or other means for circulating the heat in the room. In hot weather, ducts that provide air circulation can be used for air conditioning.

Heating by electric coils in walls, floor and ceiling is under study, but the costs are still uneconomical compared with those of the methods described above. Passing warm air through ducts under the floor and in partitions is practical, but for successful operation some means of circulating the room air must be provided. These heating methods are still being experimented with, and owners and designers are most cooperative in furthering these improvements, which former generations thought were luxuries.

Research in wiring and electrical installations has gone far. Instead of old-fashioned exposed wires held in place by tile separators, a rigid conduit makes a safe, permanent installation, if grounded and buried in the concrete floors, passed through the open web work of joists, above furred ceilings or in hollow partitions. Electric wires are pulled through the rigid conduit to complete the installation. There are many other ideas for safely carrying electric and phone wires in walls, ceilings and formed metal decks, with all outlet plugs located at preplanned locations based on predetermined office layouts. Romax flexible cable is very widely used, to mention one type.

Indirect lighting is the most comfortable, although for drafting work or where very exacting desk work is required, it is not sufficient. In such cases lighting of a diffused type is preferred. This can be provided by fluorescent lighting units, often hung above a ceiling consisting entirely of translucent plastic material to give the feeling of a solid ceiling of light. In some buildings lighting is aided by walls formed almost entirely of glass blocks that receive and diffuse daylight to all parts of the area. Glass-block walls are frequently used in industrial plants above masonry curtain walls that are run up about 5 ft to avoid exterior distraction to the working group. Wide diffusion of daylight is most desirable, and if the entrance ports for natural light are restricted, greater diffusion is necessary. It is quite common to seal off manufacturing and office areas, but the more the walls, floor and ceiling are sealed, the more necessary is air conditioning.

When considering the various trades that supply the component parts of a building, it is informative to compare their proportionate parts in the construction of the structure and, more particularly, to compare these proportions with those of twenty-five years ago. An examination of Table I shows the increased importance of the mechanical trades, clearly illustrating the great public demand for modern comforts. Also it indicates how improvements in excavating machinery and methods have reduced the proportionate cost of this part of the work. The reduced amount of brick and stone masonry is clearly indicative of the trend toward prefabricated materials for skin coverings and partitions. As has been stated, the increased cost of buildings has forced engineers to seek every possible source for savings.

In spite of the increased cost of today's buildings as compared with those of twenty-five years ago, no one would accept a new structure of the older type of design and construction. It is no longer practicable for an owner to attempt to obtain former architectural effects in brick, stone or wood, as created by the skilled craftsmen of twenty-five or more years ago. High wages would make this prohibitive even if the fast disappearing skills were available.

In the year 1955, principal features of industrial construction are improved design, better materials, and machine fabrication to accomplish faster erection. Studies are being carried on constantly to increase this trend towards "automation" in the construction industry, to use an expression popular in the automotive field.

Automation in construction has made great strides in off-the-site work, but after components reach the site, automation disappears. There are still too many on-the-job operations requiring individual manual skills and effort. All phases of the industry are working on the problem. While many job operations have been mechanized to advantage, we have a long way to go. Only time and experience in the handling of the new building components are needed for engineers, architects and constructors to find faster and more efficient ways of erecting them.

Designers and builders are pleased but not satisfied with the progress they are making in giving to the public buildings that are lighter, more airy, more attractive, and much more efficient and livable. They are no longer the heavy, bulky, drafty, inefficient structures of old. Probably they will never develop the complacent personalities of the older structures, but they will be "alive" and inspire all of us to be grateful for the revolution in building construction.

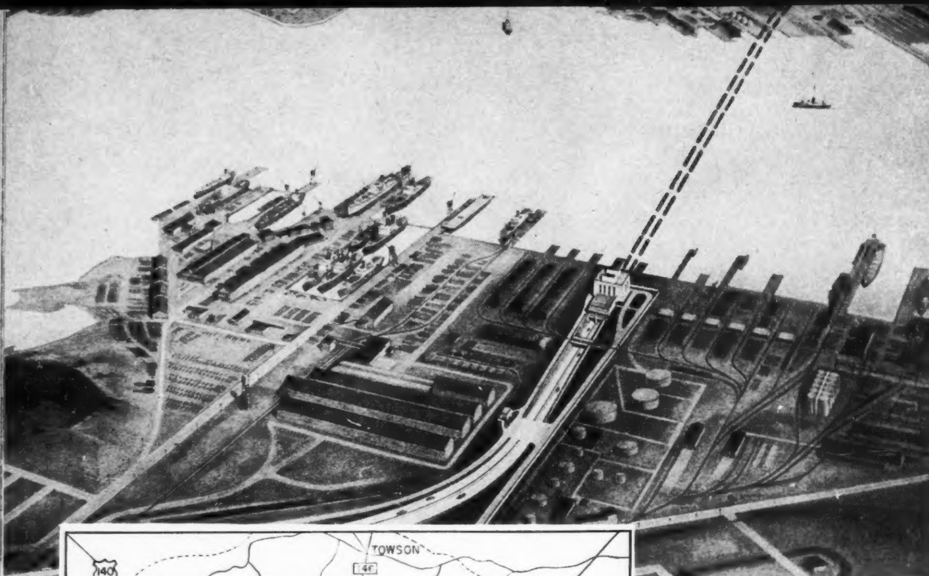
The competitive desire for improved design, better materials, and more efficient methods of construction had its roots in the depression and World War II—both of which were a source of trouble and sorrow to many. Out of these changes will come a better way of life for future generations, and the construction industry will continue to expand the market for new buildings. The best is yet to come.

TABLE I. Percentage of all trades employed in construction of a multi-story office building

(1927 compared with 1950)*

Trades or Subdivisions of Work	Percentage of Whole: 20-Story Bldg. Built in 1927		25-Story Bldg. Built in 1949–50
Excavation and foundations	7.75		4.53
Steel frame and fireproofing	16.47		16.92
Brick and stone masonry, windows and glazing	19.80		8.72
Roofing and flashing	0.39		0.45
Waterproofing	0.76		0.36
Interior partitions	5.46		8.29
Metal lath and plaster	5.00		2.32
Carpentry and millwork	1.22		1.26
Miscellaneous and ornamental metal	3.58		2.85
Cement-finish floors	2.50		1.48
Tile, terrazzo and marble	2.40		2.35
Floor coverings	0.26		0.52
Painting and decorating	1.92		0.69
Acoustical treatment	0.02		2.45
Finished hardware	0.50		0.27
Security vaults	....		0.60
Heating, ventilating and air conditioning	6.57	27.52	19.55
Plumbing	6.17		5.59
Wiring and fixtures	7.10		10.28
Elevators and conveyers	7.68	44.54	9.12
Job supervision and general expense	4.45		1.40
	100.00		100.00

* Courtesty of E. K. Abberly, M. ASCE, Turner Construction Co., New York, N.Y.

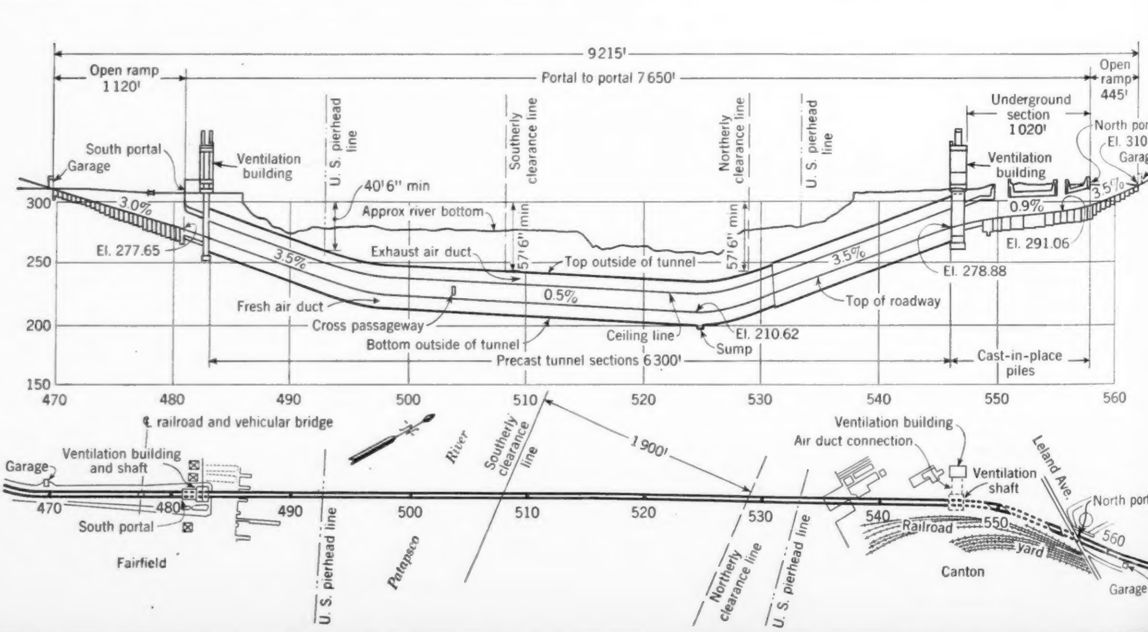


OLE SINGSTAD, M. ASCE

Baltimore's answer to urban expressway problem is twin tubes through which traffic will flow under Baltimore Harbor when tunnel, now under construction by trench method, is completed. In view above, Fairfield approach is in foreground and Fort McHenry at upper left.

FIG. 1. Baltimore Harbor Tunnel is vital link in Baltimore's urban expressway connecting important through highways on north and south.

FIG. 2. Baltimore Harbor Tunnel, seen in plan and profile, carries two lanes of traffic in each direction.



Singstad & Baillie, Consulting Engineers, New York, N. Y.

BALTIMORE HARBOR TUNNEL

Twin tubes placed by trench method

The Baltimore Harbor Tunnel is the principal structure in the new 16-mile, four-lane, limited-access expressway linking the northern and southern parts of the City of Baltimore and its most important through highways, thus enabling motorists to avoid the circuitous and congested city streets around the head of the harbor (Figs. 1 and 2). The entire route, known as the Patapsco Tunnel Project, is the fourth major project in the Maryland State Roads Commission's comprehensive Toll Bridge and Tunnel System. This system was started in 1938 with the Susquehanna River Bridge, followed by the Potomac River and the Chesapeake Bay bridges, all three now in successful operation, the latter having been opened to traffic in 1952.

Late in 1954, a 180-million-dollar bond issue pooled these three toll bridges with the Patapsco Tunnel Project, providing funds for the construction of the Baltimore Harbor Tunnel and its connecting expressways and for the redemption of the outstanding bridge revenue bonds. Traffic studies anticipate that the basic toll rate on the tunnel project will be 35 cents for passenger cars and proportionately more for heavier vehicles.

The Baltimore Harbor Tunnel is 9,215 ft long between grade points and is estimated to cost $50,000,000. The work is divided into ten construction and equipment contracts. Four of these have already been let and the rest of the work will be let in accordance with a coordinated schedule designed to keep the cost of interest during construction to a minimum. Contracts have been awarded as follows: For the river tunnel and shafts, in March 1955, to Merritt-Chapman & Scott Corp. at the bid price of $29,894,081; for the ventilation fans and motors, in June 1955, to American Blower Corp. at the bid price of $954,534; for the Fairfield approach section between the ventilating shaft and the grade point, in June 1955, to C. J. Langenfelder & Son, Inc., at the bid price of $2,206,325; and for the Canton approach section, including the foundation for the ventilation building and air ducts from the building to the shaft, in August 1955, to Leo Butler Co. at the bid price of $5,030,513.20.

Ground was broken on the principal construction contract, that for the river tunnel and shafts, by Gov. Theodore R. McKeldin on April 21, 1955, and the project is scheduled to be opened to traffic in December 1957.

Tunnel development reviewed

Development of the modern vehicular tunnel for automotive traffic, requiring an elaborate system of mechanical ventilation, antedates CIVIL ENGINEERING only slightly. Most such tunnels have been built in the 25-year period during which CIVIL ENGINEERING has been published, commemorated by this Twenty-Fifth Anniversary issue. In October 1930, when the first issue appeared, only two such tunnels were in operation—the pioneer modern vehicular tunnel, the Holland Tunnel, under the Hudson River in New York, and the Posey Tube at Oakland, Calif. The latter was the first subaqueous vehicular tunnel to be built by the trench method.

It will be seen from Table I that 14 subaqueous vehicular tunnels are now in operation, and two more, including the Baltimore Harbor Tunnel, are under construction. Thirteen are in the United States and three in Europe. This is exclusive of the four subaqueous vehicular tunnels built in Great Britain and Germany before the advent of the automobile, and such short tunnels under shallow waterways as may more properly be classed as underpasses. The table also shows that about half of the subaqueous vehicular tunnels have been built by the shield method and the other half by the trench method. The question then logically presents itself, "Why use the shield method and why the trench method?"

In the 1880's the use of the tunnel shield in combination with compressed air first made subaqueous tunneling in soft and open ground practicable. This method immediately became the standard for such work. About 20 years later, the trench method of building subaqueous tunnels was developed in the United States. By this method, prefabricated tunnel sections of considerable length are sunk in a trench dredged in the river bed, and the sections are then joined together under water. This method has two advantages—elimination of the health hazard caused by compressed air (less today, however, because of more rigid regulations), and lower cost of construction, which can result where conditions are favorable for the use of this method. Two important railroad tunnels, not included in Table I, were built by the trench method between 1906 and 1912—the Michigan Central Railroad tunnel under the Detroit River, at Detroit, 1906–1910, and the Lexington Avenue Rapid Transit Subway tunnel under the Harlem River in New York, 1911–1912. Much credit is due the late Col. William J. Wilgus, Hon. M. ASCE, and the late Olaf Hoff, M. ASCE, for the practical development, on the Detroit River tunnel, of the trench method.

Over the years significant improvements have been made in the design as well as in the technique of building subaqueous tunnels by both the shield and the trench method, but the underlying principles remain the same. The method of ventilating long automobile tunnels developed by the writer for the Holland Tunnel in the 1920's remains unchanged except for refinements in some details, and the method has become the standard for ventilating such tunnels.

Under the following conditions the trench method may be neither advantageous nor economical. The character of the river bed may be such that submarine excavation is costly; the current may be too swift for the safe handl-

ing of the large and heavy tunnel sections; the volume of water traffic may be so great and the occurrence of fog may be such that the hazard of collision between ships and the floating tunnel sections will be prominently present. Most important of all may be the damage to expensive waterfront structures and interference with important waterfront activities by the approach construction which would raise real estate costs and consequential damages above any possible saving in construction cost realized by the trench method. One of the tunnels listed in Table I was built partly by the shield method and partly by the trench method, but in considering any such combination of methods, the additional cost of two separate sets of construction equipment and the different types of labor required for the two methods must be given due weight.

At the site of the Baltimore Harbor Tunnel, all these conditions are favorable for the use of the trench method, and considering the magnitude of the project, the cost is low. This is by far the largest trench tunnel project ever carried out, because the tunnel is long and has four lanes of traffic in contrast to all other vehicular tunnels built by this method in the United States, which have only two lanes and are shorter. The only other vehicular tunnel with more than two lanes built by the trench method, is that under the Maas at Rotterdam, but it is less than half the length of the Baltimore Harbor Tunnel.

Design and construction details

The river tunnel, built in wet trench, is a double-barreled tube, 6,300 ft long, consisting of 21 sections, each 300 ft long. The tube is joined to the ventilation shafts on each side of the river. Between the shafts and the portals the structure is of steel and concrete construction, and from the portals to the surface the invert and retaining walls of the structure are of reinforced concrete construction, the latter faced with seam-faced granite.

At the Fairfield end of the tube (Fig. 2), the ventilation building is directly over the shaft and the service building is located on the roof of the tunnel structure, between the ventilation building and the portal. At the Canton portal, where the approach is located on railroad property, it was necessary to offset the ventilation building from the shaft to avoid interference with future track layouts.

Between ventilation shafts, construction of the trench tunnel includes three major stages:

1. Fabrication and launching at the shipyards of "double-barreled" welded structural steel sections, each 300 ft long.
2. Placing of interior concrete and tunnel-lining details in the sections and exterior protective pneumatic mortar on the steel shells while the sections are afloat at the "shape-up" basin (Fig. 3).
3. Towing the sections to the tunnel site and adding concrete or other ballast to sink them, under the control of derricks, into the trench previously dredged along the tunnel line. A carefully prepared foundation course of sand is previously laid and screeded to exact grade at the bottom of the trench. Also provision is made for sand or pea gravel to be forced under pressure to fill any substantial voids between the bottom of the structure and the sand bed. The tunnel sections are aligned by means of temporary masts which project above the water surface. Adjacent sections are joined by steel pins, wedges, and steamboat ratchets placed and adjusted by divers. After joining, the newly placed section is partially backfilled to ensure against flotation, and after the next section has been placed, an exterior collar of tremie concrete is poured around the preceding junction and backfilling is completed (Fig. 5).

Fabricating the shells

Three shipyards are fabricating and launching the sections. These are the New York Shipbuilding Corp., Camden, N.J., the Bethlehem-Sparrows Point Shipyard, Inc., Sparrows Point, Md., and the Maryland Shipbuilding & Drydock Co., Baltimore, Md. The twin-tube sections, each 70 ft wide, 35 ft high and 300 ft long, presented a somewhat new problem to the shipyards. Each shipyard has attacked the fabrication job enthusiastically with its own original procedure and methods. At the New York and Bethlehem shipyards, the sections will be launched endways, while at the Maryland Shipbuilding yard they will be launched sideways, a method generally practiced on the Great Lakes and continued by the Maryland Shipbuilding Co. when it moved from the shores of Lake Superior to the Baltimore area in 1920.

The cylindrical steel shells are $^3/_8$ in. thick, with exterior transverse steel-plate diaphragms $^5/_{16}$ in. thick, spaced 12 ft apart, and intermediate exterior struts and diaphragms spaced 4 ft apart. Seven-inch wide-flange T's are attached circumferentially on the inside of the tubes, 4 ft apart. The primary tunnel lining is of reinforced concrete placed inside the steel shell and designed to

TABLE I. Modern subaqueous highway tunnels of the world

Name and Location	No. of Traffic Lanes	Length, Portal to Portal, ft	Roadway Width, ft	Clear Headroom, ft	Type of Constr.	Dates Under Constr.
1. Holland, N.Y.-N.J.	4	8,557 N. 8,371 S.	20.0	13.5	Shield	1920–27
2. Posey Tube, Calif.	2	3,545	22.83	14.83	Trench	1925–28
3. Detroit-Windsor, Mich.-Canada	2	5,137	22.0	13.5	Shield 1709′ Trench 2,197′	Opened 1930
4. Scheldt River, Antwerp, Belgium	2	5,801	22.17	14.67	Shield	1930–33
. Mersey River, England	One 4-lane Two 2-lane branches	10,584 main 3,216 aggregate branches	36 main 19 branches	Arched roof	In rock, normal air; cast-iron lining	1925–34
6. Sumner, Boston, Mass.	2	5,635	21.5	13.5	Shield	1931–34
7. Lincoln, N.Y.-N.J.	4 (3rd tube, 2)	7,400 N. 8,215 orig. S. (8 008, 3rd)	21.5	13.62	Shield	1934–45 3rd tube under constr.
8. Queens Midtown, N.Y.C.	4	6,414 N. 6,272 S.	21.0 (23.5 on Manh. curves)	13.5	Shield	1936–40
9. Maas River, Rotterdam, Holland	4-roadway: 1 cycle 1 pedes.	3,512	19.8	13.8	Trench	1938–41
10. Bankhead, Mobile, Ala.	2	3,109	21.0	Arched roof	Trench	Opened 1941
11. Brooklyn-Battery, N.Y.C.	4	9,117	21.33	13.5	Shield	1940–50
12. Pasadena, Texas	2	2,900	22.0	Arched	Trench	Opened 1950
13. Elizabeth River, Va.	2	3,350	22.0	14.0	Trench	1950–52
14. Baytown, Texas	2	3,009	22.0	14.0 min.	Trench	1949–53
15. Hampton Roads, Virginia	2	7,479	23.0	14.08	Trench	Under constr.
16. Baltimore Harbor, Md.	4	7,650	22.0	14.0	Trench	Under constr.

withstand full tunnel loadings. For 4,800 ft of the tunnel length, this concrete lining is made 20 in. thick. Because of greater exterior loading requirements at the Canton end, the lining is made 24 in. thick for 1,500 ft (five sections) from the Canton shaft to the harbor bulkhead line. The twin tubes are placed 35 ft $2^3/_4$ in. on centers, the diameter of the shell being 32 ft 6 in. where the concrete lining is 20 in. thick, and 33 ft 2 in. where the lining is 24 in. thick.

Before launching, the tunnel sections are closed at each end with heavy steel plate-and-girder watertight bulkheads designed to withstand full hydrostatic head during sinking. The depth below water level of the bottom of the tube at the lowest point of the profile is approximately 100 ft (Fig. 2). Reinforced "keel" concrete approximately 3 ft thick is placed in the bottom of the sections between the bulkheads, and the pneumatic mortar protection is carried high enough to be above water when the section is afloat. Steel collar plates $^1/_2$ in. thick, similar to the main steel cylindrical shells, extend 4 ft 3 in. beyond the face of each bulkhead, making the closure between bulkheads of adjacent sections 8 ft 6 in. in length. When the exterior seal is made, steel sheetpiling or curved steel plate is placed between the vertical edges of the bulkheads as a form to retain the tremie concrete. See Fig. 5.

At the shape-up basin, interior concrete is placed, except for tunnel bench and ceiling, while the sections are moored adjacent to a pier suitably equipped with cranes, runways and other needed facilities for the operations involved (Fig. 3). Access to the interior of the tubes is provided through five equally spaced manholes in the top of each 300-ft tube, and where there is no such manhole, through concreting hatches provided in each 12-ft bay between diaphragms. The manholes and hatches are sealed and grouted when work at the shape-up basin is completed, at which time the section is slightly buoyant.

Next, the section is towed to the tunnel site, where enough exterior concrete is added to give it a negative buoyancy of 100 to 150 tons. Two to four floating derricks control the section and lower it to the bottom of the trench, where exterior concreting is completed by tremie, providing a margin of weight over displacement sufficient to ensure that the section will remain in place on the bottom. Each section, when submerged, displaces approximately 21,000 tons.

When several sections are in place and backfilled in the trench, and access from shore by ramp has been provided, the work of unwatering the spaces between bulkheads and removing bulkheads is

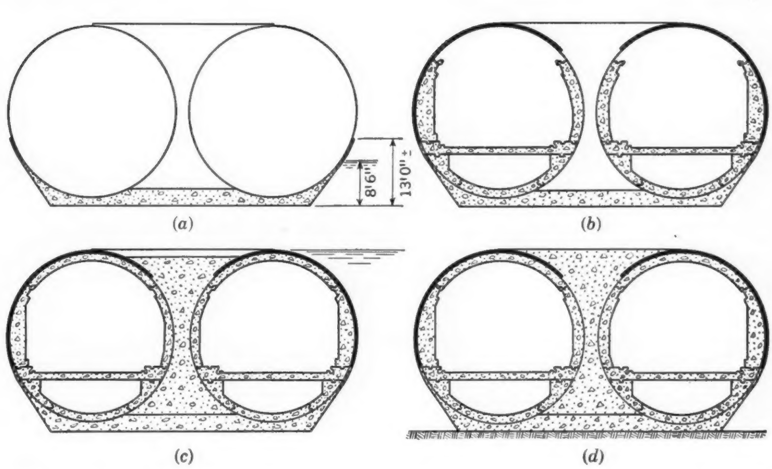


FIG. 3. Concreting of precast sections follows carefully prepared plan. Immediately after fabrication, bulkheaded sections are floated to "shape-up" basin, where concreting to almost zero buoyancy is carried out in stages, three of which are shown in (*a*), (*b*), and (*c*). After towing to site, more concrete is poured to sink it in trench, (*d*).

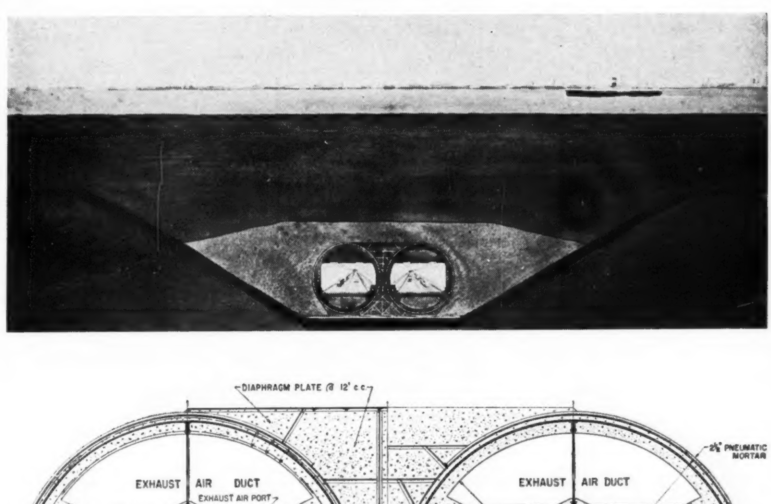


FIG. 4. Two tubes of Baltimore Harbor Tunnel are prefabricated into single section, surrounded by exterior skin, and concreted before sinking. Section at left shows steel bracing between skin plates at diaphragms, and section at right, steel bracing between skin plates between diaphragms. Sketch above shows tubes in place in trench on harbor bottom and fill over tunnel extending up to bottom of future channel.

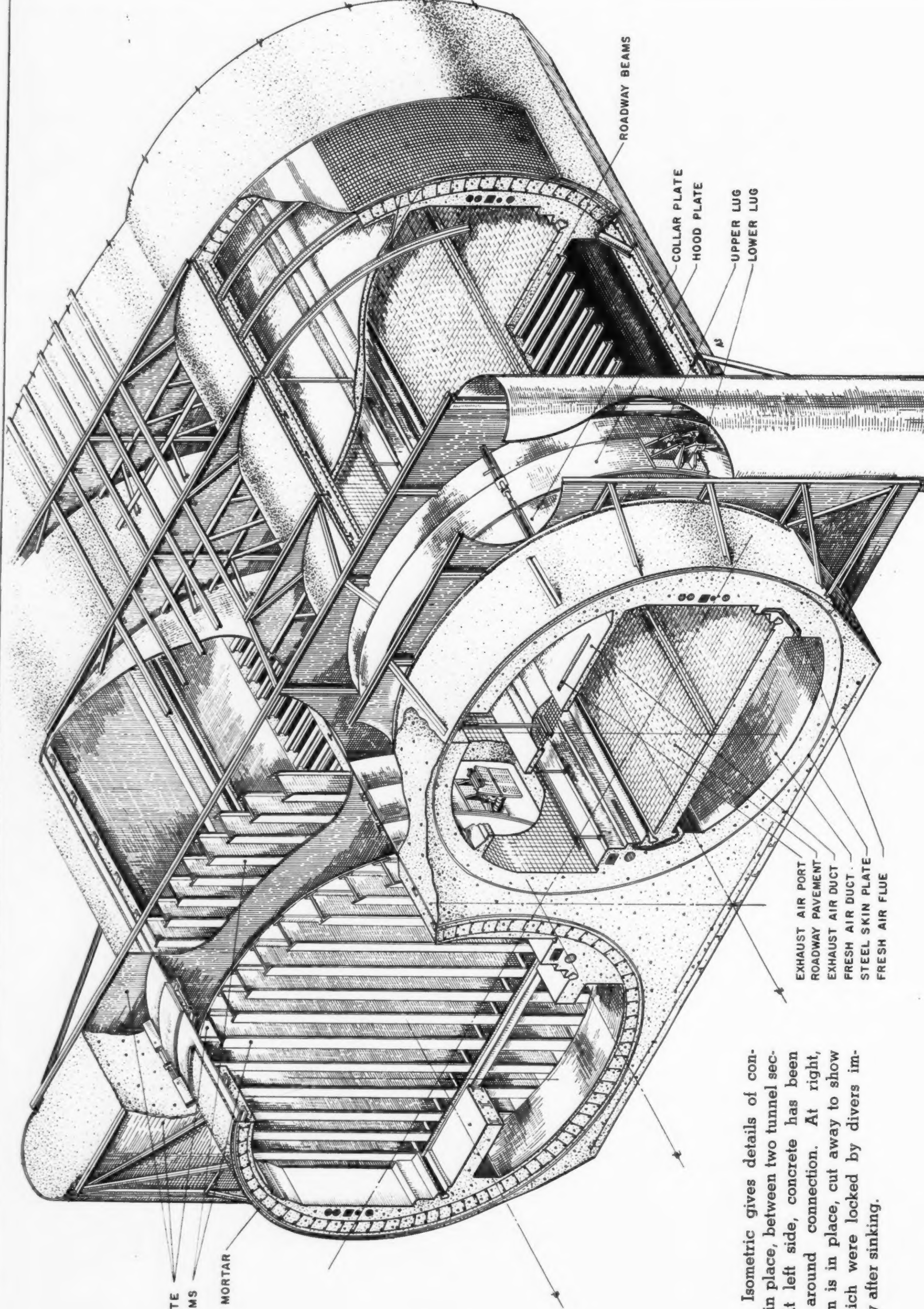
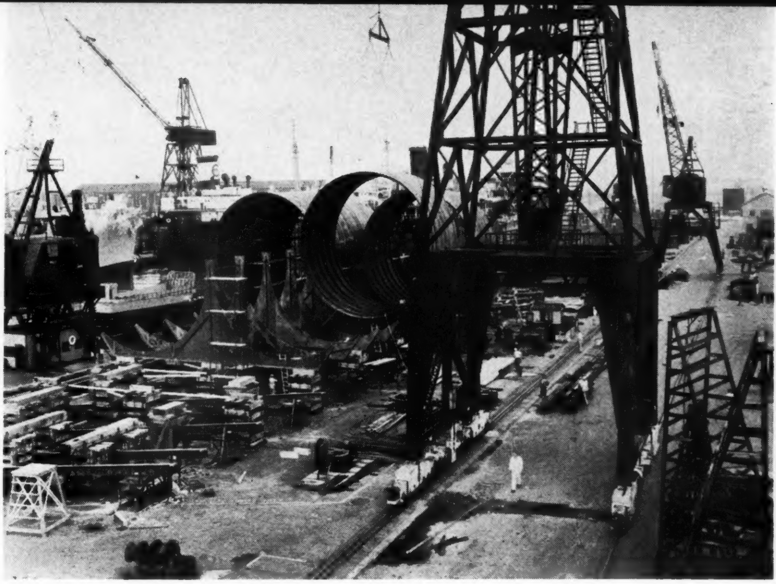


FIG. 5. Isometric gives details of connection, in place, between two tunnel sections. At left side, concrete has been poured around connection. At right, steel form is in place, cut away to show lugs, which were locked by divers immediately after sinking.



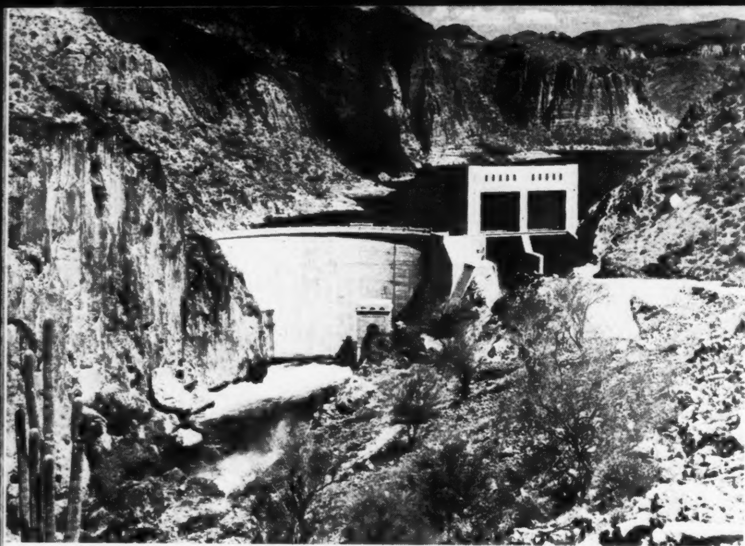
Fabrication of the steel twin-tube sections, each 70 ft wide, 35 ft high, and 300 ft long, presented a somewhat new problem to the three shipyards in which the work was done. Here work is seen under way on launching ways at: (top view) Baltimore yard of Maryland Shipbuilding & Drydock Co.; (middle view) Sparrows Point, Md., yard of Bethlehem-Sparrows Point Shipyard, Inc., and (bottom view) Camden, N.J., yard of New York Shipbuilding Corp.

commenced. After unwatering and removal of two adjoining bulkheads, the joint between collar plates of adjacent sections is spanned by a steel plate bent in the form of a channel with 3-in. legs and 1-ft 3-in. web, welded to create an annular space over the joint. This space is grouted to complete the seal. Concrete lining and interior details are then completed across the junction, followed by concreting of the tunnel bench and ceiling, omitted at the shape-up basin.

Walls and ceiling of the Baltimore Harbor Tunnel are to be finished with ceramic tile, and the roadway is to be paved with brick. The tunnel will be lighted by two lines of fluorescent lamps in each tube located just below the ceiling at each side of the roadway (Fig. 4). Ventilation is to be by the transverse distributive system. There are 8 fresh-air fans and 8 exhaust-air fans in each of the two ventilation buildings, one in Canton and one in Fairfield. Four ventilation ducts, two for exhaust and two for fresh air, will extend from the ventilation buildings to midriver. When three of the four fans on each duct are operating at full speed, a total of 3,078,000 cfm of fresh air will be delivered, or approximately 38 air changes per hour.

The first sections fabricated in each of the three shipyards will be launched in October, and the first section adjoining the Fairfield shaft will be sunk in November 1955.

The Patapsco Tunnel Project is being built by the Maryland State Roads Commission, Russell H. McCain, Chairman; Edgar T. Bennett and Bramwell Kelly, Commissioners; Norman M. Pritchett, M. ASCE, Chief Engineer; Walter C. Hopkins, M. ASCE, Deputy Chief Engineer; and the J. E. Greiner Co., Consulting Engineers. G. C. Denny is Project Manager for Merritt-Chapman & Scott. Edward V. Jones, M. ASCE, is Resident Engineer for Singstad & Baillie, whose contract with the Maryland State Roads Commission calls for field engineering supervision and inspection, as well as design of the Baltimore Harbor Tunnel.



Mormon Flat Dam was built in 1926, on Salt River below Roosevelt Dam in Arizona, for irrigation and power, by Salt River Water Users' Association. Together with Horse Mesa and Stewart Mountain Dams, it is an outstanding example of partnership for power development between local water users and Federal Government.

Powerhouse of Pacific Gas & Electric Co. utilizes falling water from Corps of Engineers' debris control dam and reservoir on Yuba River, Calif., called Narrows Project. For 9,350-kw installation, company pays $18,000 per year for first 30 years and $48,000 per year for remaining 20 years of its license.

Partnership with

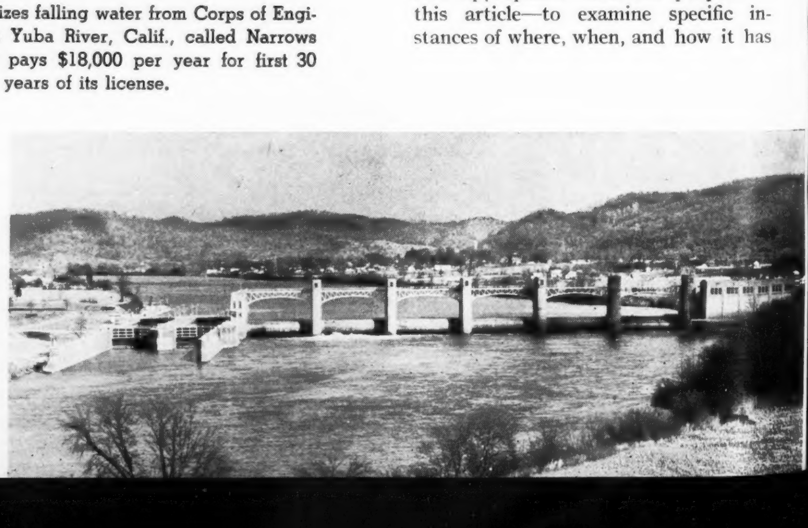
RALPH A. TUDOR, M. ASCE

During the presidential campaign of 1952, Candidate Eisenhower made a speech in Seattle, Wash., in which he supported a partnership between the Federal Government and local interests in the development of the nation's potential hydroelectric resources. He opposed domination by the Federal Government. Since this was a national campaign the subject itself, which had been a somewhat dormant political issue, then became one for extended public debate. Significantly the political cleavage is not at all definite, for members of each party have been equally vehement in support of, and attack on, the partnership concept.

In the public debate that has ensued, many explanations of the partnership plan have been given; many questions asked; many assertions made that it is unworkable; and many other assertions made that it is entirely practical. There is thus some honest confusion in the minds of many. Without any reference to the political philosophy of public versus private power, free enterprise versus socialism, or state's rights versus federal paternalism, there are a great many people who simply want to know what is meant by this partnership proposal and whether it is practical from an economic and engineering viewpoint.

If the partnership proposal were new and untried there could well be reasonable doubts and a withholding of support and judgment until some limited trials had been made. But the partnership plan is not a new idea. It has been used repeatedly over a long period and it is ready to be judged. It is therefore appropriate—and the purpose of this article—to examine specific instances of where, when, and how it has

Winfield Dam and Locks is one of three navigation structures built on Kanawha River in West Virginia from 1934 to 1936 at total cost to Federal Government of $13,175,000. Kanawha Valley Power Co. installed 43,560 kw at cost of $4,717,000 in these dams, for which it pays $104,000 per year besides delivering 40,000 kwhr per month for lock and dam operation.



Government in power production

Consulting Engineer, San Francisco, Calif.; formerly Under Secretary of the Interior

been used in the past, and to review some of the proposals now pending.

Before 1953

The partnership concept has been used for almost fifty years and during that time has not been the exclusive property of any political party. It has been utilized under every administration, since it was first employed during Teddy Roosevelt's tenure of office, and during the tenure of the present administration it has, in various instances, been supported by strong blocs in both major political parties.

As early as 1908 the Bureau of Reclamation built three small hydroelectric plants in connection with an irrigation project in the Strawberry Valley in Utah. Under an agreement with the Bureau, these plants are operated by the local water users. This general plan was repeated in 1909 at the Roosevelt Dam in Arizona, in 1911 on the Newlands Project in Nevada, in 1916 on the Yakima Project in Washington, and in 1932 on the Grand Valley Project in Colorado. In 1946 the Bureau of Reclamation made a comparable arrangement with the Pacific Power and Light Co.—a private utility—at the Cove Plant on the Deschutes River in Oregon.

In 1912, 1913, and 1914 local water users provided the funds for the Bureau to build as many power plants on the Salt River Project in Arizona. These three plants were then turned over to the local interests to operate.

Beginning in 1919 and running through 1941, the Bureau entered into partnership arrangements in six instances whereby local water-users' organizations built and operated the hydroelectric plants connected with reclamation projects built by the Bureau. Four of these were on the Salt River Project in Arizona, one on the Klamath Project in Oregon, and another on the All-American Canal in California.

A unique partnership agreement was reached between the Bureau of Reclamation and the California-Oregon Power Co. in 1917. In this instance the private power company built at its sole expense a dam and power plant on the Link River near the outlet of Upper Klamath Lake. The primary purpose of this dam is to control the level of the lake and regulate the release of water from it for irrigation of the Klamath Project and for the generation of power at the dam and in plants downstream. The agreement provided that the company would convey the ownership of the dam and the property on which it was built to the United States, but would itself operate the dam first to provide water for irrigation and thereafter to produce power. In addition the company agreed to furnish low-cost power to irrigators for irrigation and pumping. The company has an installed capacity of 3,200 kw at Link Dam and an additional amount downstream to give a total of 50,000 kw.

While the Bureau of Reclamation was making its own partnership arrangements with local public and private parties, the Army Engineers were pursuing a somewhat different course but accomplishing similar results. The Army approach was to look to the Federal Power Commission to license local interests to build power plants at navigation or flood control dams and assess charges for benefits from the falling water.

As early as 1897 a federal navigation dam was built on the Kentucky River. While the dam was capable of producing power, no equipment for this purpose was installed. However, in 1926 the Kentucky Utilities Co. sought and was granted a license by the Federal Power Commission to build a hydroelectric plant with installed capacity of 2,040 kw. For this privilege the company pays the Government $4,708 and delivers not to exceed 17,500 kwhr for lock operation per year.

In 1917 a navigation lock and dam were built by the Army Engineers on the Hudson River at Green Island near Troy, N. Y. Four years later, in 1921, a Federal Power Commission license was issued to Henry Ford & Son, Inc., and this industrial partner installed 6,600 kw. It pays $5,000 and delivers up to 600,000 kwhr per year for this use of the falling water.

In 1923 the Ford industrial interests were granted another license to install 14,400 kw of generating capacity at the navigation dam built in 1917 on the Mississippi River at the Twin Cities of St. Paul and Minneapolis. The yearly reimbursement to the Government in this instance is $95,440 and up to 60,000 kwhr for lock operation.

The Florida Power Corporation was licensed in 1924 to install a small 500-kw plant at a navigation dam built on the Oklawaha River in 1925.

In 1925 a license was granted to the Louisville Gas and Electric Co. to install 80,320 kw at a navigation dam under construction on the Ohio River. The fee is $95,000 per year and delivery of an unspecified amount of power for operation of the lock and dam.

A series of three navigation dams were built on the Kanawha in West Virginia from 1934 to 1936. These are the Marmet, London, and Winfield Dams. They cost the Federal Government a total of $13,175,000. Licenses were issued to the Kanawha Valley Power Co. to install 43,560 kw, which cost $4,717,000. The company pays $104,000 per year and is obligated to deliver 40,000 kwhr of power per month for lock and dam operation.

In 1941 the Army Engineers built the Narrows Dam on the Yuba River in California. Its primary purpose was to catch and retain debris from hydraulic mining operations upstream, and a charge was levied against miners for this service. The Pacific Gas and Electric Company was licensed to install 9,350 kw, and for the use of the falling water the company is obligated to pay $18,000 per year for the first thirty years and $48,000 per year for the remaining twenty years of the license.

Vermont has a partnership arrangement in connection with the federal flood control dam built on the Waterbury River in 1938. In 1951 the Green Mountain Power Corp. was licensed to install 5,520 kw. In this instance the State of Vermont is a third party for it operates the flood control features.

The Northern States Power Co. was licensed, in 1951, to install 8,000 kw in the Lower Dam at St. Anthony Falls, Minn., on the Mississippi River.

Thus by 1953 there were at least 26 time-tested examples of partnership in power production between the Federal Government and local interests.

They were to be found in 13 different states from Vermont and Florida on the east to Washington and California on the west. The local partners included 14 public bodies, 10 private utilities, and 2 industrial users. Twelve partnership agreements have been reached during Republican administrations and 14 during Democratic administrations. These items are tabulated in the accompanying Table I.

President Eisenhower felt, and rightly so, that the principle had been tested and found entirely workable. In order to meet the increasing demands of the industrial growth and ever-improving standards of living of the nation, and at the same time avoid increasing the federal tax burden, he strongly endorsed extension of this partnership formula.

Since 1953

A number of new partnership proposals were initiated after the Eisenhower Administration took office. Some have been adopted while others are pending.

Markham Ferry Dam

One that has been approved by Congress and President Eisenhower is the Markham Ferry Dam and Reservoir on the Grand River in Oklahoma. This was strongly supported by local interests and Senator Kerr was the driving force that successfully obtained Congressional endorsement.

Actually, the Markham Ferry project goes back several years to 1937, when the Grand River Dam Authority, a state agency, started construction of the Pensacola Dam and Reservoir on the Grand River. This combined flood control and power project cost $27,000,000, of which 60 percent was loaned and 40 percent granted to the Authority by the Federal Public Works Administration. Under a Federal Power Commission license the Authority installed 90,000 kw. This was in itself a partnership arrangement. The entire project was owned and operated by a local body made possible in this instance by funds loaned and granted by the Federal Government.

In 1938 a general plan of federal development of flood control reservoirs on the Grand River was authorized by Congress. In 1941 Congress specified that this plan should include the already built Pensacola Dam and new projects at Markham Ferry and Fort Gibson, all to be operated as a coordinated unit in the interest of flood control and power development.

Subsequently the second in this series of dams—the Fort Gibson Dam and Reservoir—has been built and is now operated by the Corps of Engineers.

In the case of the third dam, Markham Ferry, it appeared that for fiscal reasons there might well be a long wait before the Federal Government could undertake its construction. Therefore a partnership proposal was made by the local interests to the 81st Congress and again to the 82nd Congress, but without success. The legislation was finally passed by the 83rd Congress and approved by President Eisenhower on July 6, 1954.

The Markham Ferry Dam and Reservoir will be built, owned, and operated by the Grand River Dam Authority of Oklahoma. The Federal Government will contribute to the Authority not to exceed $6,500,000 to pay for the flood control features of the project. Flood control operation will be in accordance with rules established by the Army Engineers and to assure coordinated operation of the other two dams. The remaining cost of the project, estimated at about $32,000,000, will be provided by the Authority from the sale of revenue bonds secured by power revenues from this and other facilities of the Authority.

Thus there is here a partnership involving the coordinated operation of three dams built in the interests of flood control and power generation, with one dam built, owned, and operated by local interests using loaned and granted federal funds; a second dam built, owned, and operated by the Federal Government; and a third dam to be built, owned, and operated by local interests with funds partially supplied by the Federal Government and the remainder by the local interests.

Coosa River development

Another power partnership plan authorized by the 83rd Congress was that for a development on the Coosa River in Alabama and Georgia, which was approved by President Eisenhower on June 24, 1954. In 1945 there had been a federal authorization for building a series of navigation, flood control, and power dams on this river at an estimated federal cost of $60,000,000. No construction funds were appropriated and no work accomplished. In 1954 all members except one of the Alabama Congressional delegation and the Governor of the State joined in supporting new legislation for the development.

This legislation authorizes the development by a local interest, which will be the Alabama Power Co. The company has proposed to spend $100,000,000 to build the dams—probably five—and to install initially 240,000 kw with an ultimate goal of 360,000 kw. The legislation requires that basic provisions be made for future construction of navigation facilities. It also requires that provisions for flood control be made as may be found economically feasible in the judgment of the Army Engineers. Unlike the Markham Ferry Project, where a federal grant was made for flood control costs, there is no grant at this time for these costs on the Coosa River. There is only a provision that if at some future time Congress

TABLE I. Partnership projects before 1953

State	Project Name	Federal Purpose	Power Licensee or Operator	Year of License or Installation	Administration
Utah	Spanish Fork*	Reclamation	Water users	1908	T. Roosevelt
Arizona	Roosevelt	Reclamation	Water users	1909	Taft
Nevada	Lahontan	Reclamation	Water users	1911	Taft
Arizona	South Consol.	Reclamation	Water users	1912	Taft
Arizona	Arizona Falls	Reclamation	Water users	1913	Wilson
Arizona	Cross Cut	Reclamation	Water users	1914	Wilson
Washington	Rocky Ford	Reclamation	Water users	1916	Wilson
Oregon	Link River	Reclamation	Calif.-Ore. Power Co.	1917	Wilson
Arizona	Chandler	Reclamation	Water users	1919	Wilson
New York	Green Island	Navigation	Henry Ford & Son, Inc.	1921	Wilson
Minnesota	Twin City	Navigation	Ford Motor Co.	1923	Coolidge
Florida	Moss Bluff	Navigation	Florida Power Co.	1924	Coolidge
Kentucky	Ohio Falls	Navigation	Louisville Gas & Elec. Co.	1925	Coolidge
Kentucky	U. S. Dam 7	Navigation	Kentucky Utilities Co.	1926	Coolidge
Arizona	Morman Flat	Reclamation	Water users	1926	Coolidge
Arizona	Horse Mesa	Reclamation	Water users	1927	Coolidge
Arizona	Stewart Mt.	Reclamation	Water users	1930	Hoover
Colorado	Grand Valley	Reclamation	Water users	1932	Hoover
W. Va.	Marmet	Navigation	Kanawha Valley Power Co.	1934	F. Roosevelt
W. Va.	London	Navigation	Kanawha Valley Power Co.	1934	F. Roosevelt
W. Va.	Winfield	Navigation	Kanawha Valley Power Co.	1936	F. Roosevelt
Oregon	C Canal Drop	Reclamation	Water users	1938	F. Roosevelt
California	All-Amer. Canal	Reclamation	Water users	1941	F. Roosevelt
California	Narrows	Debris control	Pacific Gas & Electric Co.	1941	F. Roosevelt
Oregon	Cove	Reclamation	Pacific Power & Light Co.	1946	Truman
Vermont	Waterbury	Flood control	Green Mountain Power Corp.	1951	Truman

* Three plants.

adopts a general policy of compensating local interests for flood control navigation costs, such general authorization will be specifically applicable in this instance.

The legislation provides ample safeguards to assure a development by the local interests that will be no less effective than one carried out according to the federal plan. This project is an example of partnership where the Federal Government has authorized local development of a project that had earlier been planned and authorized for federal handling. It is partnership in the broadest sense and looks toward the greatest possible participation by local interests.

Priest Rapids Dam

At Priest Rapids on the Columbia River in Washington, another partnership plan has been authorized. This is in many ways comparable to the Coosa River plan except that at Priest Rapids a local public body is the partner while on the Coosa the local interest is a privately owned utility. Here too the project was earlier (1950) approved by Congress for federal development. It is a large project estimated in 1950 to cost $364,000,000, of which $65,000,000 would be for flood control, $10,000,000 for navigation, and $289,000,000 for power production.

In this instance the legislation, which was passed by the 83rd Congress and approved by President Eisenhower in 1954, authorizes a local public utility district to develop the project. Its plan must be approved and a license issued by the Federal Power Commission to assure optimum development of the resource.

The legislation provides that if the Federal Government requires the local utility district to include navigation and flood control facilities as a part of the initial construction, the cost allocated to these features will be paid for by the Federal Government in the form of a contribution to the district. If such features are not included in the initial construction, the district is required to provide basic features for future installation of these features and the cost of these basic facilities will be at the district's expense. Thus according to present cost estimates, the local district would finance approximately $289,000,000 of the cost, and only if the Federal Government requires initial inclusion of navigation and flood control facilities will it participate in the cost. This federal participation is now estimated at a maximum of $75,000,000.

An unusual partnership provision in the legislation is authority for the local district to have the Army Engineers act as the construction agency since the district is relatively small and has no adequate construction organization of its own.

Several other partnership proposals are now being debated in Congress but have not been acted on.

John Day Dam

One of the most interesting of these is a proposal by local interests to share in the cost of the John Day Dam on the lower Columbia River where it forms the boundary between the states of Oregon and Washington. This is a navigation and power dam estimated by the Army Engineers to cost $310,000,000 of which approximately $273,000,000 would be allocated to power production.

A group of local utilities have proposed that they advance to the Federal Government the full cost of the power allocation and that in return they receive the power from the project for a period of fifty years, less any power needed to operate the dam and its locks. In effect these utilities would pay in advance for their power, and this advance payment would be used to pay for construction. Ownership and operation of the dam would remain with the Federal Government. The federal contribution would be about $37,000,000.

The legislation under consideration is such that any local utility wishing to do so may participate in the proposal, and if there are more applicants for power than there is power available, allocation is to be made by the Federal Power Commission. It also provides that the local utilities must pay their proportionate share of the costs of operation and maintenance of the power facilities and portions of the joint project costs allocated to power.

This plan has the merit of providing the navigation facilities which are badly needed now, and the power which the Pacific Northwest will surely need in a few years, without the delay that is inherent in waiting for large federal appropriations.

It is significant to note that for the Priest Rapids and John Day Projects on the Columbia River the Federal Government would be expected to invest an estimated $684,000,000 exclusive of transmission-line costs, and to pay all maintenance and operating expenses unless some partnership arrangement is worked out. It is unlikely that this amount of money will be appropriated by Congress for this one geographical area without extended delay. If, on the other hand, the two partnership plans described above are effected, the federal contribution will not exceed $112,000,000. If navigation and flood control facilities are excluded in the Priest Rapids Dam, the federal contribution will be nearer $37,000,000. This is a much more likely amount to expect Congress to appropriate in the reasonably near future.

Trinity River Project

In northern California there is a proposal to develop the upper reaches of the Trinity River for power and irrigation. The Bureau of Reclamation has a plan which is estimated to cost $219,067,000. Of this amount $156,538,000 would be allocated to power and the remainder to irrigation, municipal, and industrial water, and fish and wildlife protection.

The Pacific Gas and Electric Co. has made a proposal that it build all the power plants and transmission facilities under the existing licensing provisions of the Federal Power Act in very much the same manner as was done in those numerous cases described in the first part of this article. According to the company estimates, this would reduce the federal investment by some $50,000,000, and during the 50-year license period it would pay the government $3,500,000 per year for the use of the falling water to generate power. This is estimated by the company to be $36,000,000 more net revenue than the Federal Government would receive from power sales if it does its own generating and sells at existing federal rates in this area. In addition, the company estimates it will pay $135,000,000 in taxes, of which $70,000,000 would be federal and $65,000,000 to state and local governing bodies.

This project was authorized just before the Congress adjourned in August. The authorization includes a condition that the Department of the Interior fully investigate the proposal of the company and report to Congress on this phase of the plan within 18 months.

This review, while probably not a complete record of all the "partnership-in-power" projects involving the Federal Government that have been accomplished or are now under serious consideration, does demonstrate that the principle has worked and how. It demonstrates that there are no serious financial or engineering problems involved. On the contrary, it shows that in many instances a partnership arrangement has been the practical means of promptly financing a badly needed multipurpose project which includes power.

Acceptance or rejection of the partnership concept is therefore a matter of political ideology, and it is on that basis that the issue is being debated and will be decided.

ELDON V. HUNT, M. ASCE

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PIPELINES . . .

a major American

There are more than 600,000 miles of pipelines in the United States and Canada transporting crude oil, refined petroleum products, natural gas, and other materials. There is a segment of this great underground system in every state of the United States and in most of the provinces of Canada. In the United States at the end of 1954 there were 186,723 miles of petroleum pipelines and 413,000 miles of gas pipelines. The corresponding figures for Canada are 3,975 and about 650 miles.

In every part of the world where petroleum or natural gas has been found there will probably be a pipeline of some sort moving these commodities to a refinery or industrial area, or to tidewater. Crude-oil pipelines have the longest history, but it is known that the ancient Chinese at one time transported natural gas in bamboo pipes for considerable distances for the purpose of evaporating water from brine to obtain the salt.

The remarkable record of progress made during the past quarter of a century reflects the application and use this industry has made of modern developments in machines, materials, and methods.

Pipelines vary in diameter from 2 or 3 in. to 36 in. and are operated at pressures up to and above 1,000 psi. This article is confined to a discussion of those high-pressure steel pipelines which are dedicated to the overland or cross-country movement of crude oil, refined petroleum products, and natural gas since these lines constitute the greatest percentage of the pipeline mileage throughout the world and especially in the United States and Canada. In passing it is worthy of note that an 8-in. pipeline is being planned in Utah to transport gilsonite ore from a mine to a processing plant a hundred miles away. The gilsonite will be ground and mixed with water making a slurry which will be pumped by a plunger-type pump operating at a discharge pressure of about 1,800 psi. A similar line for the movement of coal is now being planned by the Pittsburgh Consolidated Coal Co. to run from its mines in eastern Ohio to a power plant near Cleveland. The engineers are Ford, Bacon & Davis of New York. The line, 108 miles long and 10 in. in diameter, will probably be the forerunner of many like it. These two examples illustrate the use of pipelines for the movement of products not ordinarily moved by this method.

When the first issue of CIVIL ENGINEERING was published 25 years ago, gas pipelines were just beginning to emerge as a real factor in the distribution of this fuel. At that time the Colorado Interstate Gas Co. of Colorado Springs had been in operation only two years. When built, that line was the longest and largest high-pressure gas pipeline in existence. The main line consisted of 235 miles of 22-in., and approximately 105 miles of 18-in., lap-welded open-hearth steel pipe. Except at river crossings the line was plain-end, steel pipe in lengths of about 20 ft, joined with Dresser couplings using rubber gaskets. On the river crossings screw pipe was used with collar-leak clamps, and at each joint a specially designed cast-iron river clamp weighing about three-quarters of a ton was bolted over the coupling and collar clamp. The operating pressure on the line was about 350 psi, and deliveries to Denver and Pueblo, Colo., were about 50 million cu ft per day.

Today this system consists of more than 1,250 miles of welded steel pipe operating at pressures of more than three times that of the original line. In the same general market areas of Colorado and Wyoming, average daily deliveries on this system now exceed 500 million cu ft. The company now has under construction a 350-mile feeder line from the Pacific Northwest pipeline, which will make another 100 million cu ft of gas available to the company's rapidly expanding markets.

The Panhandle Eastern Pipeline Co., which serves much of the Midwest, recently completed its third parallel main pipeline across Kansas, Missouri, Illinois, Indiana, and Ohio. This addition to its facilities will raise the company's maximum sales capacity to 1,425,000 million cu ft per day. An important contribution to the pipeline industry was made by the engineering department of this company recently when it developed smoothly drawn nozzles in lieu of saddle-reinforced outlets at headers, valve settings, and lateral connections. The idea of using nozzles followed a study of the failure of saddle connections.

The interstate movement of natural gas in the United States has steadily increased until more than $4^1/_2$ trillion cu ft of gas was moved to market in 1954.

An example of a products pipeline development is the 25-year growth of the Great Lakes Pipeline Co. When it was boldly projected in 1930, it consisted of about 1,200 miles of line capable of moving about 18,000 bbl of products daily. Today the system has more than 5,000 miles of line with a capacity of more than 200,000 bbl daily. The original pumping stations had direct-driven reciprocating pumps which required crews around the clock, seven days a week. Some of the recently built stations have electric-powered remote-controlled centrifugal pumps, and are completely unattended.

The Interprovincial Pipeline was built in 1950 from Edmonton, Canada, to Duluth, Minn., and Superior, Wis., with a capacity of about 95,000 bbl, to move Alberta crude to markets in the east. In 1953 this line was extended to Sarnia, which made it 1,774 miles long, and its daily capacity was increased to 217,000 bbl by the installation of additional pumping capacity and loop lines. During this same period the Trans-Mountain oil line was built from Edmonton to Vancouver, a dis-

industry

tance of 718 miles, with a capacity of 150,000 bbl to supply refineries in the Pacific Coast region.

Tremendous reserves of natural gas have been developed in Alberta as a result of the extensive oil explorations there since the discovery of the Leduc oil field in 1947. These reserves are estimated at $15^1/_2$ trillion cu ft of recoverable gas and are still in their underground reservoirs, with the wells capped. To bring this gas to market, one of the most ambitious and challenging of all pipelines, the Trans-Canada, is planned. This line will carry natural gas more than 2,200 miles across the continent to the more densely populated areas of Canada on the eastern seaboard. The Westcoast Pipeline now under construction will take natural gas from the Peace River region of northern Alberta to the Pacific Northwest, thereby making this fuel available for the first time in that section. Concurrently, the Alberta Gas Trunk Line has been designed to serve as the gathering system for the eastern export of this Alberta gas. Construction of the Trans-Canada and Trunkline pipelines is expected to be under way by the fall of this year (1955).

It is expected that, in the United States and Canada, more than 56,000 wells will be drilled in 1955, of which about 12,000 will be wildcat or exploratory. The total drilled footage will exceed 225,000,000 ft for the first time. In 1945 the number of wildcat wells was about 4,200, of which 800 were successful. In 1954 about 2,100 wildcat wells were successful.

Most spectacular chapter in pipeline history was written when two lines of 20-in. pipe, spaced 1,250 ft apart, were laid across Mackinac Straits, a distance of about 4 miles, in depths up to 248 ft. Here section 2,500 ft long is prepared for pulling into position.

1

THEN—At time it was built in 1928, the 340-mile pipeline of Colorado Interstate Gas Co. was longest and largest high-pressure gas line in existence. Maximum diameter was 20 in. and operating pressure, 350 psi. Photos show: (1) horse-drawn acetylene welder; (2) steam powered side boom laying pipe in ditch; (3) man-power plus A-frame lining up sections for Dresser coupling; (4) lowering-in with A-frame; (5) tightening of Dresser coupling (on another line of 24-in. pipe), forerunner of the electrically welded joints used on today's pipelines.

2

Reasonable estimates indicated that about $27,150 million is now invested in the petroleum industry in the United States. Of this investment 71 percent is apportioned to production, $6^1/_2$ percent to transportation, 15 percent to manufacturing, $6^1/_2$ percent to marketing and about 1 percent to other uses.

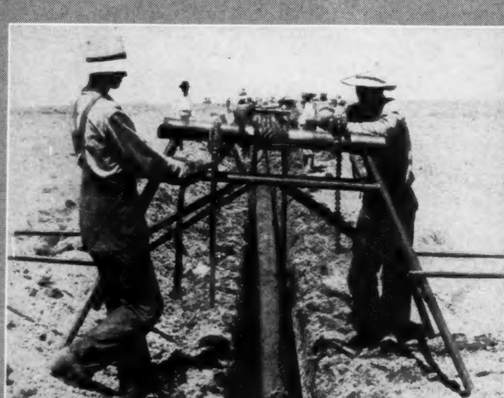
The daily demand for petroleum products has grown from about 4.2 million bbl in 1942 to more than 8.2 million bbl in 1954, and the forecast is for 8.5 million bbl in 1956.

Farm mechanization during the past decade has created an ever-increasing demand for liquid fuels and has shifted the marketing locations for refined petroleum products. At the same time, modern house heating units burning fuel oil or natural gas have added another new market capable of consuming millions of barrels of oil or billions of cubic feet of natural gas annually.

The widespread use of gasoline and diesel powered construction equipment adds its impact to this industry, besides the continuous increase in the number of trucks, buses, and private automobiles.

The general conversion of railroad motive power from coal to diesel has

3



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NOW—Modern pipeline construction is a highly mechanized, mass production operation as seen in this series of photographs showing operations of Southern Natural Gas Co. Note ever-present side-boom, trademark of pipelaying industry. From top down: (6) Ditcher cuts 6-ft trench with ease. (7) Road boring machine places section of pipe under existing roadway. (8) Self-powered cleaning machine removes mill scale, dirt, and rust. (9) Self-powered coating and wrapping machine places coat of enamel, followed by fiberglas and felt protective wrapping, while man in foreground operates fault detector which locates cracks in coating. (10) Bending machine bends 36-in. coated pipe in the field.

provided another new market for petroleum products. Since 1949 the railroads have purchased over 14,000 diesel units, 121 steam and 20 electric. In 1954 the railroads showed an increase of $7,500,000 in the purchase of diesel fuel oil, which gives them nearly three times as much ton-mile transportation per dollar as fuel oil burned in steam locomotives and about 80 percent more than coal or electric power.

During the course of the past century the consumption of energy in the United States has increased 391 percent, and since 1941 this gain has been about 42 percent. Today the aggregate consumption of energy in this country exceeds 39 trillion Btu's. Before World War II, coal constituted about 55 percent of the total, petroleum about 30 percent, and natural gas about 10 percent. In 1954 coal had dropped to 32.2 percent, and petroleum and natural gas had risen to 40.7 and 23.1 percent respectively. Natural gas now heats as many homes as coal and furnishes about 20 percent of the fuel used in the generation of electricity. The amount of natural gas used in a year is equivalent to about $31^1/_4$ million tons of bituminous coal. Pipelines transport and de-

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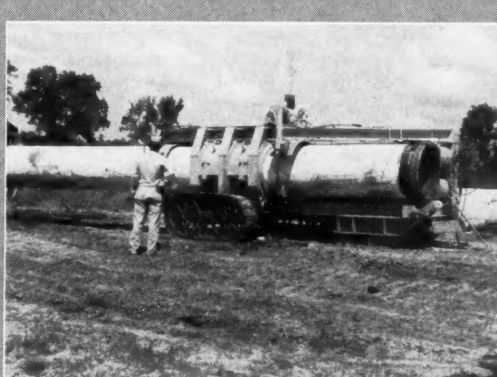

10

In Pakistan, welding and aligning crews string new Sui gas line across rolling dunes for 347 miles to connect Karachi with Sui gas field. Line was completed in little more than six months by joint venture of Morrison-Knudsen of Pakistan Ltd. and D. & C. and William Press Ltd., of London, England.

liver most of the 63.8 percent of the energy requirements of the country represented by oil and natural gas.

The growth of pipe technology has been the key to modern pipelines. The following tabulation gives a good comparison between old and new pipe:

	1928	1950
Type of pipe.	Lapwelded	Electric welded
Maximum dia.. . . .	18 to 22 in.	30 in.
Steel yield point . . .	25,000 psi	52,000 psi
Max. line pressures. .	350 psi	850 psi

Today ordinary line pipe ranges in size up to 36 in. in diameter and up to 50 ft in length, with wall thicknesses of from 0.125 to 0.500 in., depending on the pipe size. The steel from which this pipe is made developes ultimate tensile strengths up to 72,000 psi for certain grades and qualities. The 50-ft sections eliminate 26 welds per mile, which adds up to considerable savings in construction cost over long distances. Recently an announcement was made of a new grade of line pipe twice as strong as the best in use today. It is made from low-carbon martensite steel, alloyed with several other elements. This pipe, called T-1 by the manufacturer, can be ordered in two strengths. One of these has an ultimate strength of 105,000 psi with a yield point of 90,000 psi and an elongation of 18 percent, and the other has an ultimate strength of 120,000 psi with a yield point of 105,000 psi and an elongation of 20 percent. Both types are available in the standard thicknesses and diameters up to $10^3/_4$ in. outside diameter. This pipe was designed especially for use in cold countries and for far higher maximum working pressures.

The importance of pipe in the economy of the country is shown by the fact that, in the period 1954–1957, pipelines and utility companies will require more than 4,642,000 tons of steel.

Along with the improvement in pipe materials there has been a constant development in the art of electric welding, which has replaced the oxyacetylene method in use twenty-five and more years ago. Automatic welding in pipe yards is commonplace today. There, ordinary lengths of pipe are joined by submerged arc automatic welding machines. These double joints facilitate field bending and reduce hauling and field welding by nearly 50 percent.

Development of X-rays and gamma rays for the inspection of welds has made it possible to examine the interior of a weld without destroying it. These rays passing through the metal produce a picture or graph of the weld on a film placed against the opposite side of the metal. Where voids or foreign matter less dense than the weld or pipe walls being photographed are present, a greater number of rays will pass through and expose the film more at that point. Therefore voids and defects will appear as dark spots or areas in the resulting picture, and extra-thick deposits of metal will appear as light spots or areas. Using this means of examination we now can be assured of almost perfect welds in any section of a pipeline, especially in vulnerable sections at river crossings.

Progress in construction equipment

Construction machinery has also kept up with the demands of the times. Today we find special equipment devoted exclusively to pipeline construction. The list of these machines includes bending machines, ditching machines, welding machines, pipe cradles, beveling machines, bitumen heating kettles, marsh buggies, rock rippers, dredgers, and internal line-up clamps to name but a few. Among these the most spectacular and utilitarian of all is the famous side-boom tractor.

The latest to join this family of machines is the Caterpillar "Pipelayer," recently introduced after five years of research and testing. This monster, on 28-in. tracks with an 86-in. spread between them, and an overall length of $211^1/_2$ in., has a lifting capacity of 130,000 lb. In a recent field test on a pipeline construction project, one of these Pipelayers replaced two D-7 side-booms and one D-8 side-boom on a lowering-in operation for 30-in. pipe. What a contrast this offers to the A-frame and hand-operated chain hoists that were used 25 years ago to lower a pipeline into the ditch after it had been bolted together with Dresser couplings and laid on skids placed across the ditch. See a group of accompanying photographs.

Giant bending machines now make smooth, cold-worked bends which do not reduce the wall thickness of the pipe at points of bend and are capable of bending pipe up to 36 in. in diameter. Traveling cleaning machines move under their own power on long sections of welded pipe and remove the mill scale, dirt, and rust before the specially made traveling coating machines, which follow, apply the protective asphalt, coal tar, or wax coatings. Huge trenchers cut ditches up to 5 or 6 ft wide and from 6 to 7 ft deep, little affected by the loose rock and boulders encountered.

Modern pipe-laying barges and hydraulic dredges cut deep trenches in river bottoms below the scour line and lay pipelines across rivers which formerly could only be crossed on bridges. Multiple wagon-drills hanging from the boom of the side-boom tractor, and powered by large modern air compressors, now dig ditches through solid rock that once would have been bypassed in pipeline ditching operations. (A straight line is generally the most economical location for a pipeline.)

The secret of pipeline construction lies in careful logistical planning, for every day the work begins in a new place. A smooth flow of materials, good transportation, and mobility are essential to successful operations.

A contractor's organization, called a "spread," is made up of about 300 men and more than a thousand tons of special machines and equipment forming a self-contained unit closely resembling a well trained military division. The working day is from sun-up to dark seven days a week. Place or country means little to such a group. For example, the 347-mile, 16-in. gas

line just completed in Pakistan was built at the rate of more than two miles a day through more than 32 miles of solid rock, across the sand dunes of the desert, and through the irrigated rice paddies of the Indus Valley, all in temperatures sometimes reaching 130 deg.

The most spectacular chapter in pipeline history was made when two lines were laid across Mackinac Straits during the extension of the Interprovincial Pipeline previously mentioned. (See article by Clark Root, CIVIL ENGINEERING for February 1954, p. 25.) The four-mile underwater crossing between Lake Huron and Lake Michigan consists of two lines of 20-in. pipe spaced 1,250 ft apart, placed in water 240 ft deep. These are the deepest underwater pipelines in the world. The pipe was pulled across in 2,500-ft sections, made up on the shore, by a steam winch operating a single drum which handled 1,250 ft of 2-in. cable for a single pull. Dynamometers were used to indicate the tension on the pipe and cables at all times to assure that the allowable tensile strength of the pipe and pulling cable would not be exceeded. Tie-in welds were made at the water's edge for each section, and all welds in the crossing were radiographically examined. The first line was pulled across in $161^1/_2$ hours, and the second in just 65 hours.

On the Mississippi River crossing for the Gulf Interstate Gas Company's system, two 24-in. and two 16-in. lines were laid in underwater trenches more than 70 ft below the surface of the river. Approach cuts in the banks were 100 ft deep, and more than 8.5 million cu yd was dredged to make the trenches across the river bottom. Pipe lengths 120 ft long, each consisting of three sections of pipe with a concrete coating were installed at one time. These three-section lengths weighed 28 tons whereas a comparable land section of the same pipe normally would weigh between 6,000 and 8,000 lb. Welds joining these 120-ft sections were made on the rear of the pipe-laying barge. Upon completion of a weld, the barge was pulled forward and the section lowered into the water, sliding over the end of the barge. Another 120-ft section was then put in place and welded to the end of the preceding one. To prevent buckling, floats were attached to support the pipe in a proper curve from the bottom of the trench to the lowering-in barge. The cycle of setting these concreted joints on the ramp and welding, coating, concreting the joint, and lowering-in, averaged three hours.

Another unusual method of laying big pipe was developed recently on the Transcontinental Pipeline Company's expansion program using 36-in. steel pipe. Here the contractor chose the sewer-pipe type of installation and lowered one section of pipe at a time into the ditch, where the field welding was done in previously dug bell holes. The sections of 36-in. pipe weighed more than two tons each.

Location and communication

Aerial surveys are almost universally used in locating pipelines today. The method is not only fast but provides pictures of terrain features from which owner and contractor can prepare much better cost estimates for construction. Along with aerial surveys and mapping for new construction, the airplane has been adopted for patrolling the line and to move key personnel quickly in times of emergency. The helicopter is coming in for its share of this work and especially in inaccessible locations in mountainous country such as that found on the route of the Trans-Mountain oil line. Twenty-five years ago such inspection was done by line walkers who covered their sections on foot or horseback, going about 20 miles in one direction one day and returning the next. Recently the three Cesna patrol airplanes of the Transcontinental Gas Pipeline Corp. completed a million miles of patrolling that system from the Gulf of Mexico in Texas to New York.

The latest developments and electronic devices have been adopted for communication. Telegraph and telephone furnished the communication equipment on the old lines, where the line walkers and maintenance men reported to headquarters from telephone boxes hung on the poles of the telephone lines which ran parallel to the pipeline right-of-way. Today the micro-wave tower is seen on the horizon or from the tops of high hills wherever there are pipelines. Microwave facilities are now used to operate remote-controlled mechanisms such as motor valves, pumping and compressor stations, and automatic tank gages. Two-way, high-frequency radio channels are common now on all pipelines. No longer does the maintenance man or supervisor drive miles to a phone box; instead he merely lifts up the hand set in his car or truck and transmits his conversation over short-wave radio to his district or division office from any point along the line.

The capacity and performance of pumps and compressors have steadily been improved until it is quite within reason to predict that automatic and unattended pumping and compressor stations will be commonplace in the not-too-distant future. Illustrative of this progress is the change from the small steam-powered pumps of yesterday which moved about 6,000 bbl of oil a day to the 6,000-hp steam turbine-driven centrifugal pumps recently installed on a line in the Near East. These giants are capable of moving as much as 400,000 bbl of oil a day.

It is of interest to note that peak deliveries made by the Little and Big Inch lines during the war to Philadelphia and New York were 335,000 bbl of crude oil and 240,000 bbl of refined products daily. Few people realized that the Little Inch was pumping 227,000 bbl of 100-octane gasoline every day for over five months during one period of wartime operation.

Gas compressors have also undergone a change from the small steam-powered units with limited capacities and pressures to the huge centrifugal compressors driven by gas turbines which operate at discharge pressures up to 1,000 psi. The trend is toward the larger single units in pipeline compressor stations. One of the latest to enter this field is the 10,000-hp gas turbine designed and built by Clark Brothers Co. This unit can burn either gas or liquid fuel or a mixture of the two, thus making it adaptable for almost any pipeline use. The gas turbine is the power plant of tomorrow and its installation will spread as new lines are built and old ones modernized.

The many articles and papers written during the past 25 years describing materials, equipment, methods of construction, obstacles and other elements which are combined in the construction and operation of pipelines have slighted the most important factor of all—the "pipeliners." They are the people whose vision, faith, and muscle have created this ever expanding and intricate transportation system. They are a clannish group, proud of their calling, and every one possesses the spirit of the pioneer.

The markets for pipeline transmission are not exhausted nor are the energy and imagination of the pipeliners. With these assets the building and operation of pipelines will continue to be among America's most vigorous industries.

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INDUSTRIAL WASTE TREATMENT

as varied as industry

Industrial wastes are as diversified as industry itself, and their treatment has many facets. The engineer who is invited to work on industrial waste treatment will recognize the need for research to tailor the solution to the job. He has a variety of tools but must select wisely in design to assure the minimum capital commitments and operating charges for non-revenue-producing facilities. The designer of industrial-waste treatment plants must be ever conscious of cost.

Initially the job of reducing pollutional wastes is primarily chemistry and chemical engineering, with emphasis on process modifications to reduce the volume of wastes and to control their character. Eventually, when the irreducible minimum is reached, it is the sanitary engineer's problem to treat these residual wastes so that they are neither a danger nor a nuisance to the regional environment. The problem resolves itself into research, engineering analysis, economics, design, and construction—all directed toward accomplishing satisfactory and adequate treatment. Some of the major liquid-waste problems of industry will be outlined and a few examples given to illustrate present thinking on treatment practice.

Activated sludge process was first used to treat refinery phenolic wastes in 1954 by Imperial Oil Ltd., at its Sarnia (Ontario) plant, which effects 99.9 percent removal. In this view, phenol oxidation units are seen in left foreground; circular oil-water separators, in right foreground; and feed tanks, centrifuge building, and incinerator in center. Photo courtesy of Imperial Oil Ltd.

Petroleum refining

Recently installed plants for biological oxidation of phenolics, chemical flocculation of oily-waste waters, and incineration of oily sludges, chart the course for further improvement of refinery effluents.

Biological oxidation. Treatment of refinery phenolic wastes by the activated sludge process was initiated in April 1954 by Imperial Oil Ltd. of Sarnia, Ontario.[1] Although the Dow Chemical Co. of Midland, Mich., has employed biological oxidation of phenol for a period of years, Imperial pioneered in applying this process to refinery wastes. The Sarnia installation, shown in photograph, consists of a 50-ft-dia Aero-Accelator and a 30-ft-dia Accelo filter operated in parallel. The filter receives 10 percent of the flow and was intended as a source of seed in the event of serious activated sludge loss. This system was designed to treat waste containing 275 ppm phenol at a rate of 245 gpm. Feed to the treatment plant is passed through a flue-gas stripper to reduce sulfides below 50 ppm and pH to 9.0. Oil is also reduced to a minimum because of the tendency to create foam and a buoyant sludge. Nutrients are added when needed. Phenol removal has been consistently above 99.9 percent with loadings as high as 750 lb per day.[2,3]

General Petroleum Corp. included activated sludge treatment of phenolics at its new Ferndale, Wash., refinery. This plant was designed to treat 300 gpm having a phenol concentration of 200 ppm.[4] Principal units are shown schematically in Fig. 1. Ferrous sulfate may be used for sulfide and oil control. Mixed liquor from the activated sludge units is normally recycled through the external sludge aeration

Process modification goes hand in hand with effluent treatment

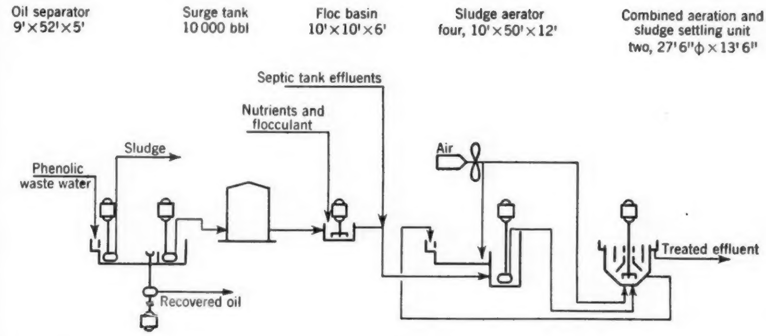


FIG. 1. Activated sludge treatment of phenolic wastes is provided by General Petroleum Corp. at its new refinery in Ferndale, Wash. Plant is designed to treat 300 gpm at phenol concentration of 200 ppm.

basins at a rate equal to the untreated waste flow. The sludge aerators receive 600 cfm air and the activated sludge units 300 cfm. Excess activated sludge is concentrated in a thickener and digested in a conventional digester.

Chemical flocculation. Atlantic Refining Co. employs chemical flocculation following oil separation at its Philadelphia refinery for further reduction of oil, BOD, and solids.[5] This 10-mgd treatment plant provides oil separation, chemical flocculation, sludge dewatering, and sludge incineration. Oil separator effluent is neutralized with slaked lime slurry and boiler feedwater treatment sludge. Aluminum chloride from a spent catalyst sludge serves as an economical coagulant with alum as an alternate. Activated silica, clay, and lime slurry are occasionally used as coagulant aids. Sludge is dewatered by means of rotary vacuum precoat filters. Sufficient oil is normally present in the filter cake to support combustion.

Chemical flocculation is also used at the Ferndale refinery for oily waters (Fig. 2). General Petroleum Corporation at Ferndale is believed to have the most complete treatment for refinery effluents thus far provided by any refinery.

Centrifugation and incineration. Imperial Oil Limited solved its slop oil-sludge problem by centrifugation and incineration (Fig. 3). The two-stage centrifuge unit was designed to handle 875 bbl per day of oily sludges and black water. The primary centrifuge of the horizontal type removes 95 percent of the solids containing 19 percent oil and 15 to 40 percent water. The second-stage centrifuge removes additional solids and breaks emulsions. The recovered oil, containing less than 0.5

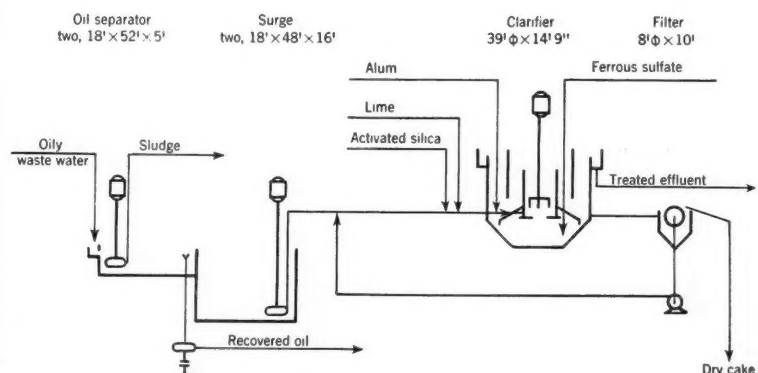


FIG. 2. Chemical flocculation for treatment of oily water is used at Ferndale refinery of General Petroleum Corp.

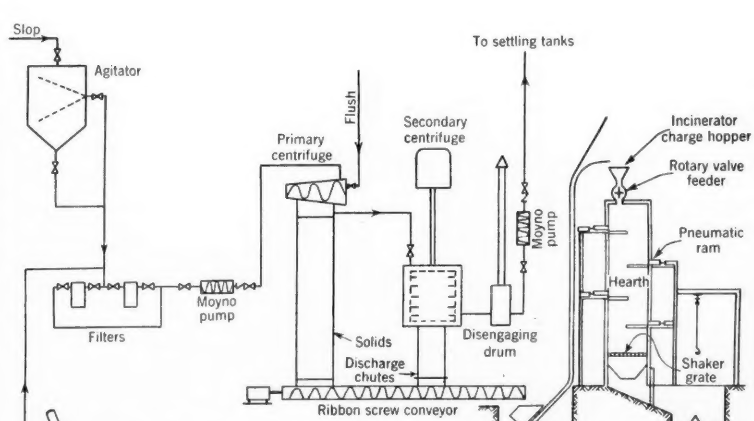


FIG. 3. Centrifugation and incineration solve slop oil-sludge problem of Imperial Oil Ltd. at its Sarnia, Ontario, plant. Two-stage centrifuge is designed to handle 875 bbl per day of oily sludges and black water.

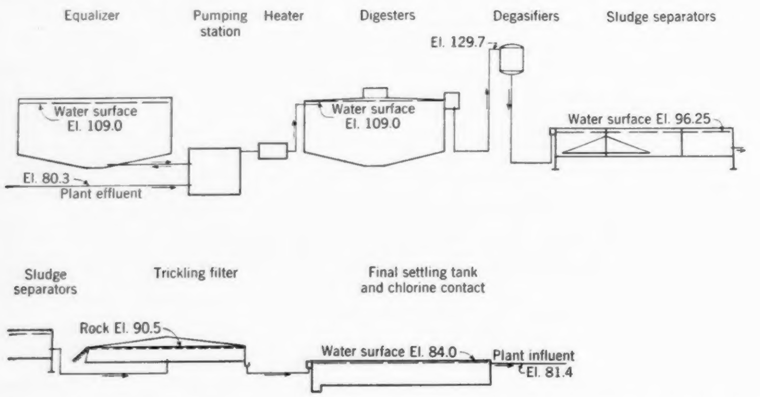


FIG. 4. Anaerobic treatment of packing-house wastes will be initiated in first full-scale unit at Albert Lea (Minn.) plant of Wilson & Co., Inc. Treatment plant is being built in two stages to permit full-scale testing of equipment.

percent water, is returned to process. After preheating, the centrifuge solids support combustion.

Automotive industry

Waste waters from metalworking normally contain miscellaneous machine oils, spent soluble oil coolants, emulsion cleaners, and suspended solids. Free oil and settleable solids are effectively removed in oil-water gravity separators but emulsified oils required special handling.

Treatment at the Chevrolet engine plant, Tonawanda, N.Y., consists of gravity separation, alum and sulfuric acid to lower the pH to 4.25, mixing and flocculation, 4-hour settling, caustic to raise the pH to 6.5, and pressure flotation.[6] Chrysler Corporation obtains a polished effluent (oil, 8.2 ppm) at Trenton, Mich., by using alum, activated silica, Colloidair separator, and diatomaceous earth filtration.[7] Dana Corporation, Ft. Wayne, Ind., employs four lagoons in series to treat 250 gpm of oily wastes. This lagoon system has a surface area of 12.7 acres and provides 51.4 days of theoretical detention. Over a 16-month period, average results showed oil reduced from 2,543 ppm to 11.5 ppm.[8]

Dairy industry

Dairy wastes have a 5-day BOD 2 to 5 times greater than domestic sewage. The high oxygen demand and ready availability of the lactose and protein of milk waste require aerobic treatment to prevent development of detrimental acidities. The most satisfactory methods of treatment are aeration, activated sludge, and biological filtration.[9] The trend is toward aeration, which is a modified activated-sludge process wherein the sludge is recirculated until stabilized. Aeration produces rapid bacterial growth and subsequent oxidation of these bacteria, at a lower rate, by their own metabolism (endogenous respiration).[10,11]

Minimum design requirements for aeration appear to be 1.0 cfm air per pound of BOD using jet-type aerators, 30-hour detention in a combined equalization-aeration tank, 2-hour final settling, and provision for continuously returning all sludge to the aeration tank with the raw waste.[12,13] Any excess sludge is relatively stable. BOD reductions by aeration have been reported as high as 97 percent. Dairy wastes can be satisfactorily treated in municipal activated sludge plants when considered in design and operation.[14,15]

Food processing industry

Lagoons and irrigation systems are the principal methods of waste disposal at present employed by the vegetable and fruit, canning, and frozen-food industries. Both ridge-and-furrow and spray irrigation are used, with the latter gaining favor as an economical and satisfactory method.[16,17,18,19,20] The principal requirements for spray irrigation are: availability of land within an economical pumping distance; a cover crop to aid absorption and to prevent erosion; a mechanically operated 10-mesh screen; a receiving tank with pumps and necessary piping. The wastes are sprayed on the land while fresh to minimize odors. It is common practice to apply from 3 to 4 in. of waste, once a week, at a rate of 0.4 to 0.6 in. per hour. Wooded areas have absorbed as much as 400 to 600 in. of water by spray irrigation over an 8-month period.

Meat industry

Liquid waste from abattoirs and packing houses are similar chemically to domestic sewage but considerably higher in solids, BOD, organic nitrogen, and grease. The 5-day BOD of these wastes may range between 500 and 5,000 ppm, depending on salvage efficiency and water consumption.[21,22] A bibliography and summary of treatment methods has been published.[23,24]

Chemical treatment appears most satisfactory for small abattoirs operating on intermittent slaughtering schedules. Pilot-plant studies in Pennsylvania have demonstrated a 95-percent BOD reduction using chlorinated lime and alum.[25] The sludge problem is normally not serious for the smaller plants.

Trickling filters have proved dependable and effective for medium sized and larger plants. The washable roughing (trickling) filter has been included in the design of several treatment works with BOD loading rates ranging from 6,000 to 8,000 lb per acre-ft per day.[26,27] They are frequently followed by conventional filters.

Activated sludge has been used for years to treat packing-house wastes after they have been diluted with large volumes of sewage. The process has been successfully applied to the undiluted wastes.[28]

Anaerobic treatment has recently been applied to packing-house wastes with striking efficiency and economy. Extensive pilot-plant studies conducted at the Geo. A. Hormel & Co. plant at Austin, Minn., have demonstrated that the process is capable of removing 95 percent of the 5-day BOD and 90 percent of the suspended solids at loadings up to 0.20 lb of BOD per cu ft of digester volume per day.[29] These removals have been accomplished with detention periods in the digester of less than 12 hours, based on the untreated waste flow.

The first full-scale unit for anaerobic treatment of packing-house wastes is under construction at the Albert Lea, Minn., plant of Wilson & Co., Inc.[30] Design criteria for this treatment works are:

Equalizing tank at 100 percent equalization has capacity of 27 percent of total flow.
Heaters (two) maintain digesters at 95 deg F.
Digesters (two) have capacity of 0.15 lb of BOD per cu ft per day and 0.15 lb of volatile solids per cu ft per day.
Degasifiers (two) remove all the methane and most of the CO_2. Design is for 20-in. vacuum.
Separators (two) provide 1:1 to 3:1 sludge return at 600 gpd per sq ft of surface loading.
Trickling-filter rate of application is 23 mg per acre per day and BOD loading is 2,600 lb per acre-ft per day.
Final clarifiers (two) have surface loading of 800 gpd per sq ft.

The profile of the plant as designed is shown in Fig. 4. This treatment works is being built in two stages to permit full-scale testing of equipment. The first stage includes the two digesters, one sludge separator, and the control building.

The degasifiers, to improve settling, are believed to be the first used in waste treatment. Their design was based on deaerators commonly used for feed-water at steam generating plants. Sludge from the separators is withdrawn by Tow-Bro mechanisms, and excess sludge is lagooned.

Steel industry

Departments of an integrated steel mill which produce significant liquid wastes are by-product coke, blast furnace, and rolling mill.

By-product coke. Cyanogen compounds and phenols are the most objectionable constituents recognized in by-product coke wastes.[31] The cyanide problem has been effectively handled in most plants by employing a closed recirculating system for the gas final cooler water. Water losses from evaporation in the cooling tower of these systems normally exeeed that condensed from the gas.

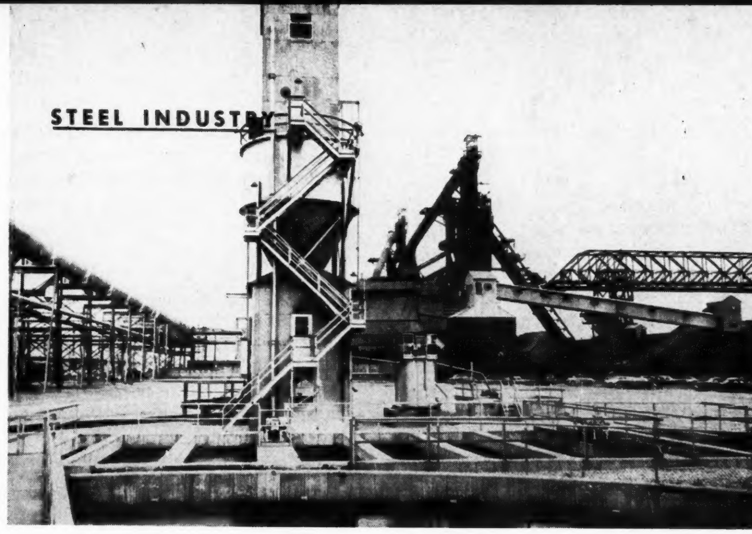
The ammonia still discharge is the principal source of phenols in by-product coke wastes. Two methods in common use for reducing phenols in plant effluents are:

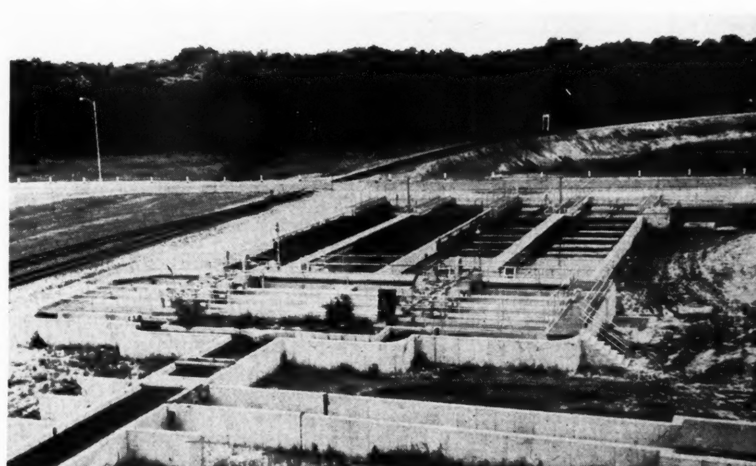
1. Evaporation of phenolic wastes by coke quenching.
2. Recovery of phenols by benzol extraction or steam distillation.

Coke quenching with a closed recirculating system eliminates the waste except for traces of phenols which are adsorbed on the coke and carry over to the blast furnace gas wash-water.[32] A number of benzol-extraction dephenolization systems have recently been installed. This process extracts phenol from the ammoniacal liquor ahead of the ammonia still. Efficiency of benzol extraction may be as high as 98.8 percent.[33]

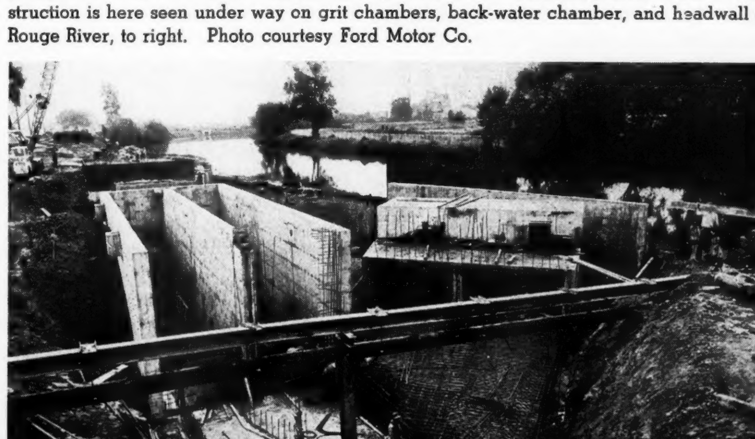
Blast furnace. Suspended solids in blast-furnace flue-gas wash-water consist of fine particles of ore, coke, and limestone. The solids when dewatered and sintered are suitable for a part of the blast-furnace charge. Plain sedimentation will recover as much as 95 percent of these solids. Coagulants and coagulant aids are used at some plants to augment plain sedimentation.

The U. S. Steel Corp. employs a highly efficient system for recovery of blast furnace solids at the Fairless Works. This plant, shown in a photograph, provides essentially three stages of treatment—primary settling, mechanical flocculation with lime, and final clarifying.[34] Theoretical detention in each unit is: primary thickener, 1 hour 20 min; flash mixer, 1 min; flocculator, 25 min; final clarifier, 2 hours. Sufficient lime is added to maintain the pH between 8.0 and 8.2. Suspended solids in the clarifier effluent are normally less





At Fairless Works of U. S. Steel Corp., most modern methods of waste recovery and treatment are used. Blast-furnace solids are recovered in highly efficient three-stage process (view above). Stages are essentially primary settling, mechanical flocculation with lime, and final clarification of blast-furnace gas wash-water. Edge of circular clarifier is in immediate foreground, with rectangular tank for mechanical flocculation just beyond. Flash mixer is to right of lime handling facilities. In photo below is seen part of terminal treatment plant for rolling-mill wastes, which get unique treatment. They pass with other mill wastes from oil-interception plant to terminal treatment plant, of which inlet flume is in left foreground; four aeration chambers in parallel, in center foreground; and four basins for sedimentation and oil removal, in center background. Photos courtesy of U. S. Steel Corp.



For removal of fine scale and oil from steel-mill wastes, Ford Motor Co. recently installed pumps and two 110-ft clarifiers operating in parallel at its Dearborn, Mich., works. Construction is here seen under way on grit chambers, back-water chamber, and headwall at Rouge River, to right. Photo courtesy Ford Motor Co.

than 30 ppm, and iron is less than 10 ppm.

Rolling mills. Discharge from mills rolling a variety of products may be expected to contain acids, alkaline solutions, soluble and insoluble oils, and mill scale. Good practice calls for treatment of these wastes near their sources. Partial treatment can frequently be accomplished by controlled mixing of certain wastes. Neutralization of spent pickle liquor with lime is practiced widely by the industry.[35]

The treatment provided for rolling-mill wastes at the Fairless Works is unique in many respects.[34] Oil and acid wastes are concentrated in one area for treatment, that is, in the oil-interception plant, which includes among other units a standard A.P.I. oil-water separator. Treated wastes from this area combine with other mill wastes and receive further treatment in the terminal treatment plant; the first unit is shown in a photograph. This secondary treatment includes aeration, presedimentation, and oil removal. Effluent from this plant is directed to a sedimentation basin providing 4 hours of detention, thence to a lagoon for an additional 4 hours of storage before release to the Delaware River. The terminal lagoon may well be used by other industries as a barrier to alleviate pollution.

Scale pits are designed to remove only heavy, readily settleable mill scale. The Ford Motor Co. has recently installed pumps and two 110-ft-dia clarifiers at Dearborn, Mich., for removal of fine scale and oil from steel-mill wastes. A photograph shows this plant under construction. The two clarifiers, operating in parallel, provide a theoretical detention of 30 min at the 80-mgd design flow rate.[36]

Textile industry

Extensive research has been conducted on textile wastes.[37,38,39,40,41] Extreme variations in manufacturing operations complicate their treatment. Prospects are favorable for waste reduction by in-plant process control and by individual waste treatment. Use of low BOD process chemicals and treatment of highly alkaline wastes with flue gas are examples. Pilot-scale biological treatment of highly alkaline wastes with domestic sewage shows promise.

There appears to be a definite trend toward combined treatment of certain textile wastes with domestic sewage. The Sugar Creek sewage treatment works, Charlotte, N.C., placed in operation during July 1955, has a heavy industrial load, with textile wastes predominating. This plant was designed for an average flow of 11 mgd and an equivalent population of 177,200. Principal treatment units include pre-aeration, primary clarifiers, trickling (roughing) filters, activated sludge, secondary clarifiers, sludge digestion with external heaters and heat exchangers, sludge drying beds, and chlorination.[42]

The city of Kannapolis, N.C., in cooperation with Cannon Mills Co., is at present converting the municipal plant from standard to two-stage high-rate biological filters to permit treating a considerable part of the textile dying and finishing wastes.[43]

Chemical precipitation is frequently employed to augment plain sedimentation even though the sludge problem is magnified. Odors from treating high-sulfur textile wastes can become serious.[44]

Calcium chloride treatment of wool scouring wastes at three plants in Massachusetts has been reported as giving BOD reductions of about 70 percent and grease removals well over 90 percent.[45,46]

Tanneries

Characteristics of tannery wastes are known and various treatment methods are in use.[47,48,49] Combined treatment with domestic sewage is common practice where municipal facilities are available.[50,51,52] The minimum treatment normally consists of mixing all wastes, sedimentation with removal of sludge, and discharge of the clarified waste continuously at a uniform rate. Efficient sedimentation may be expected to remove 90 to 95 percent of the settleable solids and 40 to 60 percent of the BOD.[53] The BOD removal can be increased substantially by separation and storing of the spent tanning liquors and by providing for their controlled release during high stream flows. The vegetable tanning liquors sometimes represent almost half of the total BOD.

Lagooning of sludge is common practice. Centrifuges are used to concentrate sludge at the Keystone Tanning & Glue Co., Inc., Ridgeway, Pa. Use of vacuum filters for dewatering tannery sludge has been reported.

The International Shoe Co. tannery at Bolivar, Tenn., uses two large earthen basins for primary sedimentation of 0.75-mgd mixed tannery and domestic wastes. Each basin is approximately 200 ft by 500 ft and 4 ft deep. They are operated at a depth of only 18 in. because of the difficulty in drying deeper beds of sludge. Theoretical detention approximates two days when the basins are clean. The basins are used singly and alternated each week. Ferri-Floc, a hydrated ferric sulfate, is used at the rate of 1,000 lb per day for odor control. Removal of sludge by dredge-type equipment is contemplated.

Two vegetable tanneries located in the Cowanesque River valley in Pennsylvania dispose of settled tannery wastes by spray irrigation. Discharge from one tannery was reported as 1.4 mgd and from the other, 0.33 mgd. The soil is alluvial underlain by a deep deposit of glacial gravel. The entire flows are evaporated and absorbed. There is no vegetation on the sprayed area.[53]

Metal plating

Concentrations of plating chemicals in baths are usually in the range of 0.1 to 2 lb per gal. Rinse-water concentrations range from 40 to 100 ppm. Spent plating baths may be bled slowly into, and treated with, rinse waters. Strong cyanide solution facilities should never be drained directly to sewers.[54]

Chemical methods predominate in treatment. These include:

1. Control of pH to:
    a) Break oil emulsions
    b) Increase reaction rates
    c) Prevent formation or evolution of dangerous gases
    d) Precipitate metallic constituents
2. Neutralization of acids and alkalis
3. Oxidation of cyanides (Fig. 5)
4. Reduction of hexavalent chromium (Fig. 6)

Automatic control of chemical dosages (Figs. 5 and 6) is used extensively. Conventional methods, as applied to other industrial wastes, are used for oil removal, and strong acid and alkali neutralization. The acids and alkalis may be used for pH control in treatment of cyanide and chromium. Oxidation of the cyanide liberates and, with proper pH control, precipitates the metals (Fig. 5). Many oxidizing chemicals have been used, with alkaline chlorination gaining greatest popularity.[55,56] The first application of about 3 lb of chlorine per lb of cyanide converts cyanide to cyanate. The second, of about 5 lb per lb, completes the cyanide destruction. About 1.25 lb of caustic per lb of chlorine are needed. The pH is controlled in the range of 8.5 to 10.0, with 8.6 optimum for metal precipitation. Cadillac Division of General Motors Corp., at Detroit, Mich., uses alkaline chlorination to convert cyanide to cyanate and completely automatic controls for strong acid and alkali neutralization.

Sulfites are commonly used to reduce hexavalent to trivalent chromium (Fig. 6). Sulfuric acid is applied to assure rapid reduction at pH 2.5 to 3.0. An alkali, usually lime, adjusts the pH to about 8.5 to precipitate trivalent chromium. Chemical dosages are approximately:

Sulfur dioxide	2 lb per lb of chromium
Sulfuric acid	1.5 to 2.0 lb per 1,000 gal of waste
Lime	1.5 to 2.0 lb per 1,000 gal of waste plus 2.5 lb per lb of chromium

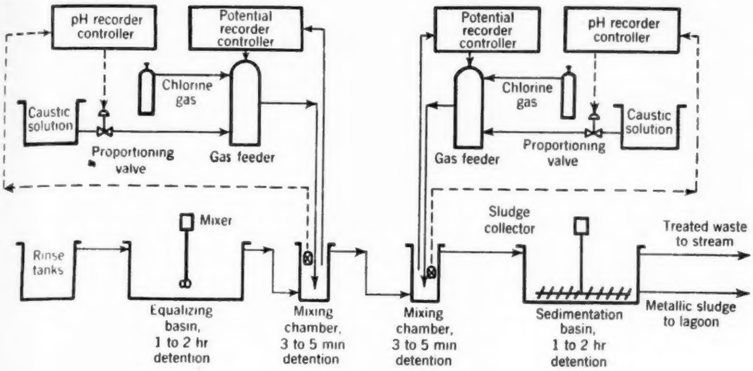


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FIG. 5. Cyanide wastes from metal plating are completely destroyed by alkaline chlorination process, seen in typical schematic diagram. Chemical feed is entirely automatic.

FIG. 6. Hexavalent chromium wastes from metal plating are treated by sulfite reduction process, seen in typical schematic diagram. Chemical feed is entirely automatic.

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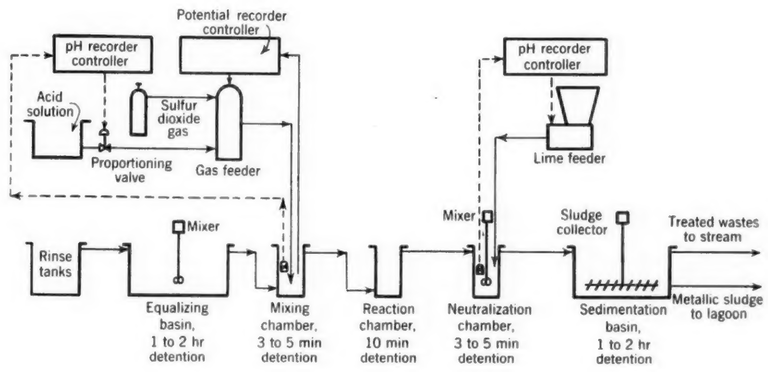


The General Electric Corp., Appliance Park, Ky., and Electric Auto-Lite Co., Sharonville, Ohio, are among those using sulfites for chromium treatment.[57]

Possibly no other plant has tried, and used, so many different methods of treatment as Talon, Inc., Meadville, Pa.[58] The Douglas Aircraft plant at Oklahoma City, Okla., is an excellent example of modern design, treating cyanides with alkaline chlorination and chromium with sulfur dioxide under completely automatic control.[59] A few plants have vacuum filters for dewatering sludge, but the majority discharge sludge to lagoons.

Ion exchange for recovery of plating metals is being used to a limited extent. Although profitable in some large shops, equipment and operation costs and operating simplicity need to be improved to make the method attractive to smaller shops.

Paper industry

Significant developments have been made recently in the treatment of pulp-mill wastes.

Kraft mills. Activated sludge treatment of kraft-mill wastes at Covington, Va., is one of the most significant recent developments in the handling of wastes from the paper industry.[60] Much credit is due the West Virginia Pulp and Paper Co. for application of the principles of biological oxidation first demonstrated for these wastes by the National Council for Stream Improvement.[61,62,63] This company's two-million-dollar treatment works (Fig. 7), placed in operation in May 1955, treats all wastes from the woodyard to about midway through the bleaching process.

Similar to other processes throughout the mill, the need for low operating costs, good control, and high efficiency dictates the use of instrumentation wherever practical. The normal flow of 16 mgd has an average 5-day BOD of 140 ppm to the aerators. Aeration of 3 hours is provided with 25 percent return sludge. Mixed liquor concentration varies between 0.2 and 0.3 percent. Based on the average concentration, the aerator BOD loading is 56 lb per thousand cu ft. Air requirements approximate 1.0 cu ft per gal of waste. Nitrogen and phosphorus nutrients are added as needed to maintain 1 lb of available nitrogen for 20 lb of BOD, and 1 lb of phosphorus for 75 lb of BOD. The primary tank is 100 ft in diameter with 12-ft side water depth. Activated sludge units have a 175-ft diameter, with aeration channels 25.5 ft wide and 15 ft deep. During initial operation in June 1955, this plant accomplished 85 percent BOD reduction treating 60 percent of the wastes.

Residual wastes from the National Container Corporation's new kraft mill near Valdosta, Ga., are treated in alternating settling basins followed by two oxidation lagoons in series. The settling basins receive fiber-bearing waters after passage through a flotation save-all. Strong non-fiber-bearing wastes are collected in an equalizing basin from which they are pumped at controlled rates and blended with the effluent from the settling basins. Fish life in the small receiving stream attests to the efficacy of the treatment.

Sulphite mills. Calcium-base sulphite waste liquor, the No. 1 pollution problem of the industry, is being attacked from many angles. Wisconsin sulphite mills in particular have made good progress in utilization of waste liquor. During 1954, these mills processed 513,200,000 gal of sulphite liquor by evaporation and burning, the Howard process, soil filtration, road binder, and torula yeast.[64] This represented approximately 60 percent of all collectible liquor produced by the 14 mills included in the Sulphite Pulp Manufacturers' Research League.

Charmin Paper Mills, Green Bay, Wis., has recently completed a new torula yeast plant substantially larger than the Rhinelander installation. The potential demand for feed supplements ranges into millions of tons annually but there are many other products competing for the market.

Sulphite roadbinder is attracting increasing interest in Wisconsin and adjoining states. During 1954, 60 million gal of sulphite liquor from Wisconsin mills were converted to roadbinder.

Ten of the fifteen sulphite pulp mills in Wisconsin have adopted soil disposal or are conducting experimental evaluations of this method as a means of pollution abatement.[65]

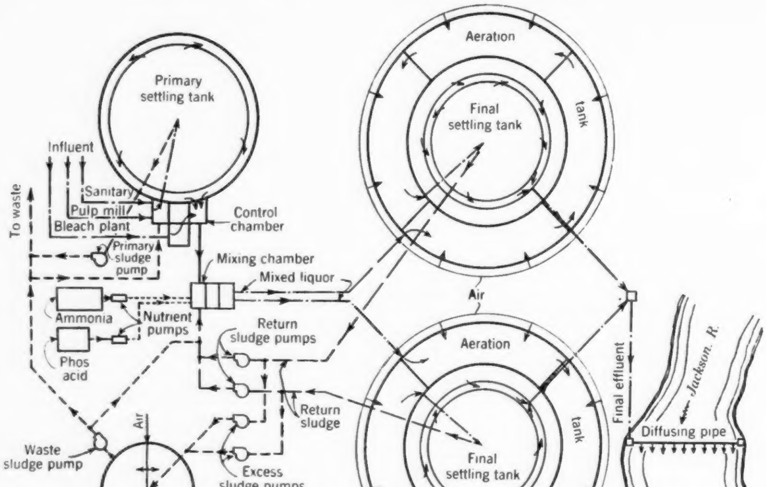


FIG. 7. Activated sludge treatment for kraft-mill wastes is one of the most significant recent developments in handling of wastes from the paper industry. Flow diagram, reproduced by courtesy of West Virginia Pulp & Paper Co., shows process at its Covington, Va., plant, for which Gibbs & Hill were consulting engineers. Use of instrumentation wherever practical is a feature of this plant.

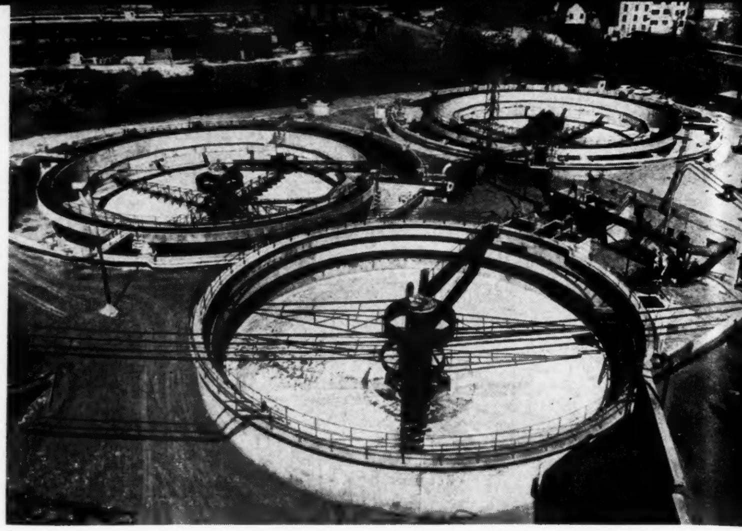


Photo shows plant for which flow diagram is given at left. Primary clarifier is in foreground, with two Dorr-Currie secondary clarifiers beyond. Mixing chamber and control building are at right center.

In the Pacific Northwest, interest has been growing in the use of soluble bases, particularly magnesium and ammonia. Evidences of this interest are the MgO process developed by Weyerhaeuser Timber Co., Longview, Wash., and the ammonia base process installed by Crown Zellerbach Corp., Lebanon, Oregon.

Pharmaceuticals

The advent of antibiotics was closely followed by laboratory and pilot-plant waste treatment studies.[66,67,68,69,70,71] Because of their high soluble organic content, biological filtration preceded by aeration has been generally adopted for these wastes. Combined treatment with domestic sewage is satisfactory when the capacity of the municipal plant is not exceeded. Disposal into deep injection wells has recently been reported. An activated-sludge plant has been constructed by Abbott Laboratories but operation data are not available.

The Willow Island, W. Va., waste treatment plant of American Cyanamid Co. is of particular interest because of its compact and flexible design and the concentration of wastes treated. This plant treats wastes from fermentation processes producing crude pharmaceuticals and feed supplements and a small amount of sanitary sewage. Aeration and two-stage biological filtration give an overall plant BOD reduction greater than 90 percent when treating 90,000 gpd of wastes having an initial 5-day BOD of 5,700 ppm.[72]

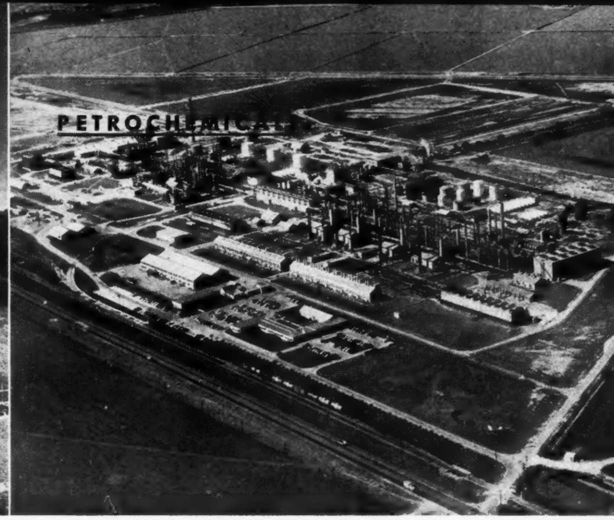
Design of this plant, shown in a photograph, was based on experience in treating similar wastes at the company's Lederle Laboratories.[73] Twelve-hour aeration of the raw waste, to which has been added sludge from the secondary clarifiers, serves to condition the wastes for further treatment.

Aerators and primary clarifiers remove about 60 percent of the BOD. The BOD loading on the primary filter averages 2,800 lb, and on the secondary filter 1,300 lb, per acre-ft per day. Each filter removes approximately 60 percent of the applied BOD with recirculation rates of 1.5 to 1. BOD loadings may be as high as 5,000 lb per acre-ft per day but sustained loadings of this magnitude may result in clogging growths on the filter. Operations at this plant indicate that a 1,000-ppm, 5-day BOD should be a safe ceiling concentration for these wastes as applied to the filters.

The Upjohn Company, Kalamazoo, Mich., also uses aeration and trickling filters for treatment of penicillin and streptomycin wastes.[74,67] These process wastes are mixed with a considerable volume of domestic sewage, giving a combined waste of about 1,500-ppm, 5-day BOD in a flow of some 200,000 gpd. The Upjohn filters are operated in parallel but provision was made for series operation and for reversing the order. The Upjohn plant has 25 percent more filter stone than the Willow Island unit and applies a weaker waste at a higher rate. Overall plant efficiencies are comparable.

In October 1954, the Upjohn Company placed in service two deep injection wells at Kalamazoo for the dis-

Pharmaceutical fermentation wastes are treated by aeration and two-stage biological filtration at Willow Island (W. Va.) plant of American Cyanamid Co. In foreground are two 80-ft-dia high-rate biological filters, final clarifiers, and pumps; in background, control building, aerators, and primary clarifiers. Overall BOD reduction is better than 90 percent at 90,000 gpd. Photo courtesy American Cyanamid Co.



Shallow ponds dispose of petro-chemical wastes by solar evaporation at Bishop (Tex.) plant of Celanese Corp. of America. Average evaporation rate is 1.2 gpm per acre. Ponds are about 3 ft deep. Photo courtesy Celanese Corp. of America.

posal of fine chemical wastes from the manufacture of cortical steroid products. These wells penetrate the Traverse and Dundee brine strata located at depths of 1,300 and 1,400 ft respectively. The pretreatment plant designed to handle 150,000 gpd provides pH adjustment, flocculation, sedimentation, and filtration. Well-head pressure varies between 500 and 900 psi, depending on the number of pumps and wells in service. Disposal of 80,000 gpd has been reported.[75]

Petrochemicals

Manufacture of industrial organic chemicals produces a process waste water containing traces of most of the major products. Some of these substances are highly persistent in streams. Celanese Corporation disposes of these wastes by solar evaporation at its Bishop, Tex., plant, shown in a photograph. The average net evaporation rate in this area is reported to be 1.2 gpm per acre. These ponds average about 3 ft in depth and have gunite-lined dikes with a 6-in. curb at the top to help control foaming during high winds.[76]

Monsanto Chemical Co. reports effective pollution control by integrating waste disposal into manufacturing operations for each product or group of products.[77] Incineration of organic wastes plays a major role at the company's Texas City, Tex., plant. When burning of wastes is not feasible, chemical treatment, steam stripping, or other appropriate treatment is employed. Several manufacturers of organic chemicals report direct firing of small-volume, high-concentration water wastes to boilers. The continuing rapid expansion of the petrochemicals industry makes the waste problem one of major proportions.

Trends reviewed

Summarizing, it can be said that biological treatment has a great potential for many dilute organic wastes. The intensive activity in increasing aeration efficiency should encourage application of the activated sludge process. High-rate biological filters of the alternating double type should find increasing favor. Engineers in industry have many chemical processes on which to draw, and some of these are useful in waste reduction and treatment.

Soil disposal by spray irrigation and lagoons is attractive for industries that operate seasonally. It should prove effective for any industry in reducing the waste load during critical streamflow periods. Interest in this method of waste disposal is accelerating.

Automatic controls and instrumentation are extensively used in many industrial-waste treatment plants. These are an aid to operation but the education of process engineers as to the limitations of the waste treatment plant is of equal importance. Control at the source and treatment of final effluents are inseparable functions.

The foregoing discussion is based on ideas gleaned from many sources. The writer wishes to acknowledge material assistance from several state, municipal, and consulting engineers. Industrial and manufacturers' representatives have been especially cooperative in furnishing detailed information. The writer is most grateful to all who have contributed.

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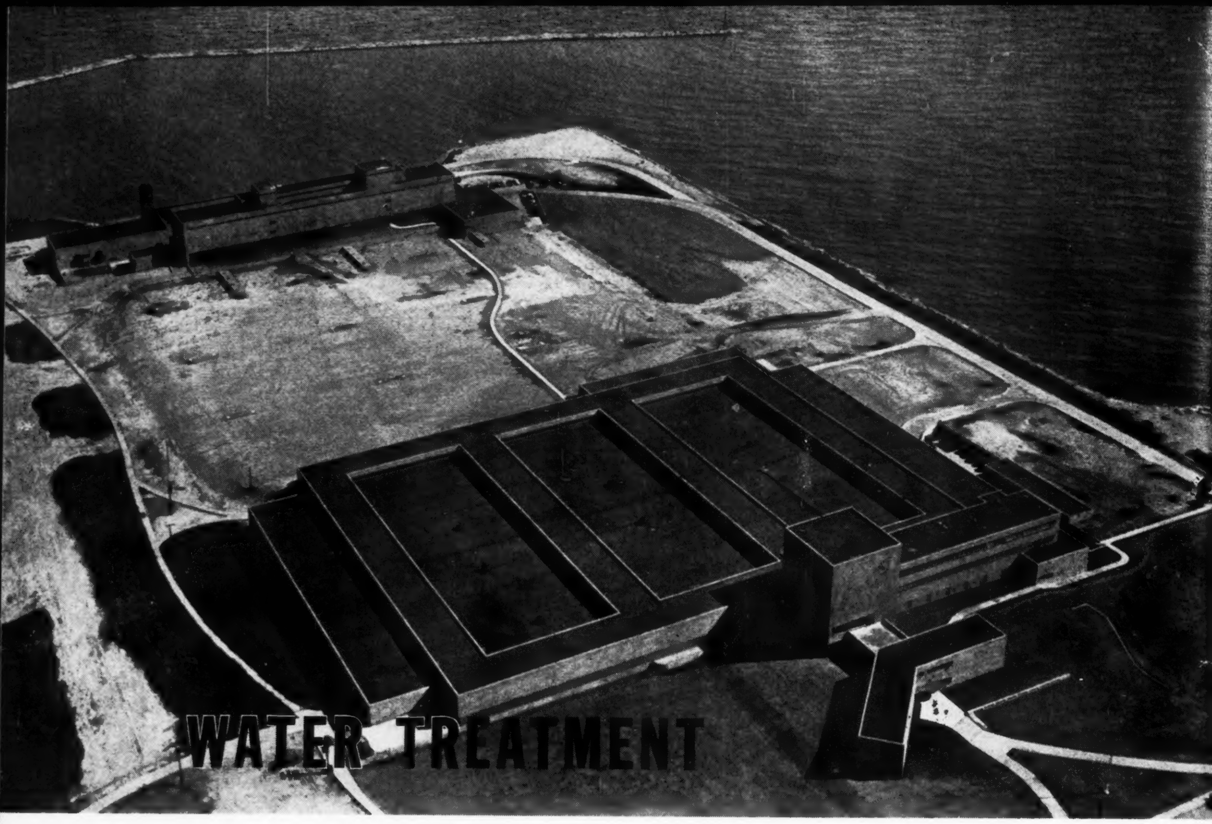


WATER TREATMENT

reaches high stage of development

L. R. HOWSON, Vice President, ASCE, Alvord, Burdick & Howson, Consulting Engineers, Chicago

Purification of American water supplies is at an all-time high as to both quality and quantity. This stature has been reached by an evolutionary development which is still going on, but which was largely achieved during the past half century. The cost of filtration for the average family is about a half cent a day.

Rapid sand filtration, with efficient pretreatment to reduce the load on the filters, is an accepted American practice. All surface waters for domestic consumption should be filtered.

Mechanical mixing and a longer mixing period have superseded mixing by velocity change.

Presedimentation has been discarded and coagulation and settling-basin design so improved as to deliver to the filters a water low in both bacteria and turbidity, leaving only the final "polish" for the sand filters, and the final bacterial "kill" for chlorination. Mechanical cleaning of basins has largely replaced manual cleaning at plants handling turbid waters and at softening plants.

Cleaning of filter sand has progressed from the low-rate water wash, aided by mechanical stirring, to the high-rate water wash usually aided by surface wash.

Chemical feed, originally in solution, has passed through a dry-feed stage and is now returning to solution feed, at least for alum, in many of the new and larger plants.

Until thirty years ago effective efforts to reduce taste and odor were largely confined to aeration, now little used. Today many plants spend more for chemicals (activated carbon, chlorine, and ammonia) to control tastes and odors than for purification chemicals.—*L. R. Howson.*

Rapid sand filters have evolved as most efficient method of treating domestic water. World's largest filter installation is Chicago's South District plant, with capacity for treating 320 mgd of Lake Michigan water.

For several decades practically all new water filtration plants have been of the "mechanical," or "rapid sand" type. Similarly the new developments and practices have been in this type of filtration as distinguished from slow sand filtration.

Mechanical filtration is purely an American development to meet the requirements for treating the generally turbid waters of this continent. It is an illustration of the use of ingenuity and engineering analysis to accomplish the desired results at less cost than was practicable with the European practice of slow sand filtration.

The term "mechanical filtration" was given to this rapid sand type because the sand was cleaned by mechanical means, whereas the European slow sand filters were cleaned manually. The development of mechanical cleaning of the sand passed through several stages, such as the use of jets of water applied on or just below the sand surface, mechanical rakes, reversed-flow wash and various types of stirring and agitating devices, including compressed air.

The early mechanical filters were of the pressure-tank type and were essentially strainers. The sand and gravel were contained in steel tanks which, because of the internal pressure, were usually of relatively small diameter. Originally these filters were used without coagulent. In 1884 a patent was issued to Hyatt on simultaneous coagulation and filtration. This procedure was largely used for several years although it early showed itself to be unsound in principle. Subsequently the coagulation and filtration processes were separated, and much of the progress that has since been made has been in treating the water before filtration, known as pretreatment.

The most important milestone in the develpoment of rapid sand filtration was the famous "Louisville experiments" conducted from 1895 to 1897 under the direction of the late George W. Fuller, M. ASCE. Mr. Fuller's staff included such well known names in the water purification field as Robert Spurr Weston, Joseph W. Ellms, and George A. Johnson, all members of ASCE, now deceased. Fuller's experiments demonstrated that:

1. A combination of sedimentation, coagulation, and filtration was correct in principle and that subsidence should be employed to its proper economical limit.

2. Where turbid waters are to be treated, the suspended matter should be removed, in so far as practical, before the water reaches the sand layer, and at that point the water should be thoroughly coagulated.

3. Alum was the most suitable coagulant experimented with (and it is the one most widely used today).

4. For economy of operation, individual filters should be much larger than the small circular steel filters formerly used, the limit in size to be determined by the successful operation of mechanical appliances to stir the sand layer effectively while it is being washed by the reverse flow of water.

The first concrete filters were designed by Fuller for the Little Falls plant of the East Jersey Water Company, completed in 1902. This plant included 32 concrete filters each with an area of 360 sq ft (1 mgd at 2 gpm per sq ft). Louisville completed a 35-mgd plant in 1908 consisting of three filters of 12 mgd each. Filtration at Louisville was satisfactory but the cleaning devices were ineffective and the wash-water distribution was not uniform.

In 1906 the City of Cincinnati installed the first major plant (112 mgd) having filters washed by high-rate water wash—20 in. to 24 in. per min of vertical rise, without any stirring devices. Two years later the Louisville 12-mgd units were divided into 6-mgd units and provided with high-rate water wash. Thus the basic principles of rapid sand filtration were developed.

From a small beginning with a few steel tanks, usually of 1/4-mgd capacity or less, the filtration plant has grown until today individual filters may have capacities of 6 mgd or more. One plant has been designed to treat 960 mgd, and the total number of treatment plants of this type exceeds 5,000. This progress is a tribute to American engineers and health agencies in their effort to make America a better place in which to live. Filtration has had much to do with the lowering of the typhoid death rate and is largely responsible for the fact that few urban communities are now without a safe water supply—one that is also clear and sparkling in physical appearance and usually of satisfactory mineral content.

A forceful illustration of the effect of filtration on the typhoid death rate was provided when the Niagara Falls filtration plants were constructed in 1912. Niagara Falls, being on the river some 20 miles downstream from Buffalo, in a reach where the flow was very rapid, and the time interval therefore very short between the Buffalo sewage outfall and the Niagara Falls water intake, had a typhoid death rate for the ten years prior to filtration averaging 125 per 100,000 and a maxmium of 185. For a period of 18 months shortly after the filters were installed, no typhoid deaths were reported, and in the 10 years following filtration, the average typhoid death rate was less than 5 percent of what it had been in the preceding 10 years. Most of the cases that did occur, it is stated, were not traceable to the Niagara Falls water supply.

At Cincinnati the average typhoid death rate was 59 per 100,000 for the five years prior to filtration as compared with 11 for the next five years.

Water treatment as practiced in the United States at the present time is essentially a tailor-made process utilizing the basic principles enunciated by Fuller over fifty years ago but developed in an evolutionary way in their application to specific locations and waters. It is believed that all surface waters should be filtered and eventually will be. Aside from a few notable exceptions—such as Boston, New York and San Francisco, which rely on chlorination—most surface supplies, regardless of the isolation of the source, are now being filtered.

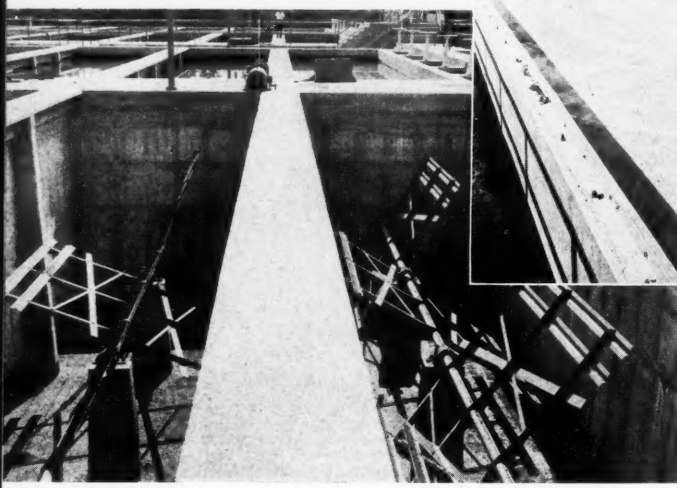
Present-day water purification works normally include the following facilities—intake, mixing and coagulation, sterilization and filtration—terminated by clear-water reservoir storage.

Every part of a water treatment plant should be designed to carry out its proper proportion of the clarification and purification work to be performed. This proportion, however, varies with the character of the water, its degree of uniformity, the chemicals adapted to its treatment, temperatures and temperature ranges, and strength of coagulation. The trend in design for many years has been toward better and more efficient methods of pretreatment, resulting in a progressive reduction in the load on the filters.

Pollution and turbidity are, of course, not synonymous. Where grossly polluted waters are treated and the filters are relied on to perform a major part of the purification process, particular attention should be given to the efficiency of the pretreatment.

With each improvement in the purification process, the standard set by the consuming public has been raised. Whereas originally filters were used largely to remove turbidity, their more important functions have now become bacterial removal and the control of tastes and odors. Pretreatment today accomplishes most of the clarification. In many filtration plants the water going to the filters from the pretreatment processes would, from the physical standpoint, have been acceptable as final effluent a few decades ago.

Modern equipment for chemical mixing provides a mixing time varying from a half hour to an hour. Pictured is one section of four flocculators recently installed ahead of sedimentation basins at new 40-mgd treatment plant of Savannah, Ga. Savannah River water is flash mixed, coagulated, settled and filtered for color and turbidity removal.



Equipment for continuous sludge removal is standard for softening plants. Installation here shown is in 200-ft square, upward-flow clarifier in water-softening plant at Louisville, Ky.

Self-cleaning intakes and presedimentation

Intake design of course varies with location and the conditions encountered. River intakes are designed in so far as possible to be self cleaning, with low entrance velocities and with openings so located with respect to the direction of currents as to reduce the amount of leaves and other trash reaching the intake. Most of the larger river intakes are provided with washable traveling screens.

It has been found in the Great Lakes that low entrance velocities and a water depth of 40 ft or more at intake ports are the best safeguards against interruptions to service by anchor ice. Velocity of inflow at intake ports should not exceed 3 in. per sec. Where both these conditions cannot be met, two intakes should be provided. The South District filtration plant in Chicago can take water either through the intake tunnel from Dunne crib, about 3 miles off shore, or through ports built into the lake wall of the plant. The new 960-mgd Central District plant is being similarly designed.

Evanston, Ill., which has frequently experienced intake stoppage from ice, is now laying an auxiliary intake. Kenosha and Racine have emergency intakes. Milwaukee, with its intake in a 67-ft depth of water, and with slow port velocities, has never had any difficulty.

In the Louisville experiments, presedimentation was included in the experimental studies. At that time sedimentation ahead of coagulation was considered worth while. As better facilities for feeding chemicals, mixing and coagulation, were introduced, and operating experience accumulated, it became apparent that presedimentation was rarely if ever economically justified and was not necessary for adequate purification. The utilization of mechanical equipment to continuously remove sludge from coagulation basins has practically eliminated any justification for presedimentation of even the most turbid waters.

Chemicals—handling and storage

Alum is still the principal coagulant. Quantities normally vary from about $^3/_4$ grains per gal for Great Lakes plants to 2 or 3 grains for river waters, still higher amounts being used where color removal is a problem. Originally nearly all plants used alum purchased in lump form, dissolved in tanks, and applied to the water in solution. Some thirty years ago, with the development of feeders for dry chemicals, there was a shift to granular alum, using dry feeders for measurement and application directly to the water. Within the past few years concentrated liquid alum has become available in many localities, and where there is a source within about one hundred miles, delivery by tank truck is usually more economical than the use of dry alum. Liquid alum is stored in lead-lined tanks.

In softening plants requiring large quantities of chemicals—principally lime—the chemicals are usually unloaded from cars to storage and sometimes from storage to feeders by conveyor equipment, usually of the vacuum type. An installation with a capacity of 8 to 10 tons per hour can usually be provided for \$30,000 to \$35,000.

For softening plants treating quantities up to about 50 mgd, the chemicals are usually delivered to, and stored in, elevated steel or reinforced concrete bins from which they pass by gravity through weight-controlled feeders and slakers, or solution boxes, to the mixing basins. In most of the larger plants where elevated storage is costly, ground storage is provided in addition to the elevated bins. With this arrange-

Milwaukee's water treatment plant, completed in 1938, has capacity to filter 200 mgd from Lake Michigan. Here shown is one of 32 filter units, which are largest built to date. Each can handle $6\frac{1}{4}$ mgd at 2 gal per min per sq ft of filter. Jets provide surface washing prior to backwash, and central gullet carries off wash water. ←

Operating tables controlling filter units are seen in operating gallery of Des Moines water treatment plant, which provides softening and iron removal. →

ment, a vacuum conveyor system transfers the chemicals from the surface to the elevated bins.

Mixing takes time

It is now generally appreciated that good mixing is a function of both time and velocity. Today a more liberal allowance is generally made for mixing time.

Many types of mechanical mixing devices are now on the market. All appear to give good results so long as adequate time is provided, and thorough dispersion of the chemicals and proper velocity of movement are obtained. Since the optimum velocity may change with a change in water temperature, water quality, or method of treatment, it is essential that all equipment be designed so that different velocities can be obtained. The optimum velocity for best results cannot always be determined precisely from laboratory prototype tests, but must be determined by actual plant operation In most present-day plants a detention time of from 30 to 60 min is provided in the mixing basins.

In softening plants, careful attention should be given to the location at which the lime solution is added to the water. Application ahead of restricted openings which create a velocity change in the flow usually results in the deposition of a hard deposit which further reduces the opening, increases the velocity, and eventually disrupts the hydraulic design.

Sedimentation basins

The detention period in sedimentation basins is, of course, influenced by raw-water turbidity, temperature, and in softening, by the nature of the mineral content. It can however be stated that the present tendency is to increase the detention time in conventional sedimentation basins to a range of 3 to 5 or 6 hours. The variation in detention period required for turbid waters is materially less than formerly because of better mixing and the more general use of continuous sludge removal equipment. Such equipment makes the full basin capacity continuously available instead of allowing sludge to accumulate, thus gradually reducing the useful basin capacity.

In a water softening plant, the velocity of flow in sedimentation basins should be maintained at a uniform rate after the chemical is added to prevent the accumulation of heavy calcium carbonate deposits on the walls of channels or basins. Even restricted gate openings should be kept to a minimum.

In the design of the conventional type sedimentation basin, the length of the overflow weir is of major importance. Thus a circular or square basin has the advantage, for it has the longest perimeter per unit of volume. In some rectangular basins it has been found advantageous to construct additional troughs or finger overflow weirs. Similarly large circular basins may require radial or interior circular overflow weirs in order to increase the length of weir available and thereby decrease the overflow rate. It is desirable to keep the overflow rate below 20,000 gal per day per ft of weir.

Mechanical sludge removal

The desirability of providing sludge removal equipment is always a point of discussion in connection with the design of settling basins. In a water softening plant, where large quantities of sludge are produced, such equipment is essential to maintain continuous operation. Otherwise large capital expenditures would be required for extra basin capacity to permit the shutdown of one set of basins for cleaning while

still maintaining the necessary plant capacity. Accordingly it is now almost universal practice to equip softening-plant basins for sludge removal. In a plain water purification plant such is usually not the case, for a very much smaller quantity of sludge is produced and cleaning is required much less frequently.

From a purely economic standpoint, mechanical sludge-removal equipment usually cannot be justified in a purification plant unless a high value is placed on the wishes of the operators and the elimination of a periodic, messy clean-up job. A study for the design of the new Central District filtration plant in Chicago, for a capacity of 960 mgd, showed that automatically cleaned basins would involve an additional initial investment of \$2,190,128, an increased operating cost of \$3,623 per year, and an increase in total annual costs, including operation, interest and depreciation, of \$174,777 per year—the equivalent of almost \$175 per year per mgd of rated capacity. Other studies in which the fixed charges on the investment required for the equipment were compared with the costs of basin capacity made unavailable by deposits, the value of basin capacity lost during cleaning and the cost of labor and flushing water, showed similar results varying only in degree. Even with such an economic situation, there is an increasing tendency to install mechanical sludge removal equipment on account of the mounting cost of labor and the desire to avoid a distasteful cleaning job.

There have been a number of partial installations in which the inlet end of the basin, where sludge accumulation is heaviest, is equipped for mechanical sludge removal while the other part is left for manual cleaning at longer intervals.

Suspended-solids contact basins

In the design of mixing and sedimentation basins, a major question in recent years has been whether to use conventional designs or the upflow, suspended-solids contact clarifiers. The choice between the two types of clarifiers is, in the last analysis, determined by the type of water and method of treatment and by an evaluation of working efficiencies, flexibility, and results in terms of cost. In general, upflow suspended-solids contact basins have been incorporated in an increasing number of softening plants but have not made corresponding progress in plants built for purification only.

There are about a dozen suppliers of equipment for the upward-flow type of basin. The various manufacturers have each adopted certain designs, on the basis of which their equipment is offered. Competition is keen and has resulted in the adoption of as short contact periods and as high rates of flow as the manufacturers feel they can safely recommend. This has necessarily reduced the ability to absorb shock loads. In general, they have recommended the reduction of detention periods to 1 to $1^1/_2$ hours. Experience has indicated that, in most cases, a detention period considerably longer than this should be provided with this type of equipment when water containing much non-carbonate hardness is to be softened. This is particularly true if magnesium salts are an important constituent, and if the supply is drawn from surface sources in the northern part of the United States. Longer detention periods are also necessary to meet the range in turbidities found in most American rivers. An upflow rate not to exceed 1 gal per min per sq ft of surface area, with a minimum detention period of two hours, is believed to represent sound design practice for suspended-solids contact clarifiers.

A study of the capacity and loadings of such clarifiers covering a period of over three years was made by a committee of the American Water Works Association. The committee reached two general conclusions: (1) that this type of installation is particularly adaptable to calcium carbonate precipitation reactions; and (2) that, while it is theoretically possible to produce a softened water chemically stable in calcium carbonate whenever a large enough calcium carbonate surface and sufficient time are provided, there is no evidence that such chemical stability is generally obtained. In some installations it has been necessary to recarbonate and accept an excessive growth on the grains of filter sand, or to use calgon.

Filters and filter rates

For the past 50 years, nearly all filters have been built of concrete, the size and number of filter units being largely determined by plant capacity, flexibility, wash water requirements, and disposal of wash water. The first plant in Louisville had units of 12-mgd capacity. These were unsatisfactory because of a lack of understanding of the hydraulics of back wash-water distribution, and because the mechanical sand stirring devices then used were ineffective.

Since that time, high-rate water wash has entirely replaced mechanical stirring of the sand, and the hydraulics of back wash-water distribution have been the subject of much research and empirical development. As a result it is now believed that the maximum size of individual filters in large plants is limited only by economic considerations.

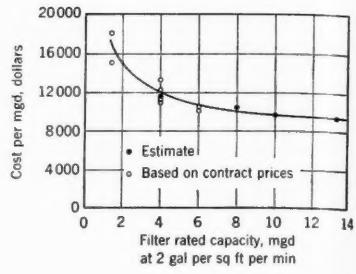


FIG. 1. Relation between filter size and filter equipment cost is plotted, per unit capacity. Filter equipment cost includes gallery piping.

A marked saving in cost results from using the largest filter units that will give the desired flexibility. See Fig. 1. Comparative estimates for a recent 36-mgd plant showed a saving of \$109,000 would be realized by providing six 6-mgd units instead of nine 4-mgd units. Studies made for Chicago's 960-mgd Central District plant showed decreasing costs per mgd for units up to 10 mgd, and little change from 10 to $13^1/_3$ mgd. The largest units built to date are those at Milwaukee, of $6^1/_4$ mgd, based on a rate of 2 gpm per sq ft.

The major question recently discussed in connection with the design of rapid sand filters, is what filtering rate to adopt. The conventional rate of filtration originally adopted as a result of the pioneer Louisville experiments previously discussed was 2 gpm per sq ft of filter area. The work of John R. Baylis, A.M. ASCE, in Chicago, has shown that a rate as high as 5 gpm per sq ft can be tolerated if the water is properly conditioned before it reaches the filters, and if no unfavorable conditions, such as high algae counts, occur. Other plants where the hydraulic design would permit, and which were relatively free of algae troubles, have been similarly operated for short periods of time.

The increased cost of a filter plant designed for 2 gpm over one designed for 3 gpm per sq ft is only 5 to 7 percent. Since, with proper hydraulic design, both can operate at a 4-gpm peak rate, this small increase in cost provides three times the peaking rate flexibility and greater assurance that the rating can be maintained under any algae conditions likely to occur. The additional factor of safety afforded by designing for the 2-gpm rate is believed to be conservative and good practice for most waters.

Pleasing architectural treatment is combined with good functional design in water filtration and pumping plant for Springfield, Mo., serving 100,000 people. Engineers were Alvord, Burdick & Howson.

Largely as a result of John Baylis's research in Chicago, and experience at many other plants, the present tendency is to specify a somewhat coarser filter sand than formerly. Sand having an effective grain size of 0.45 to 0.55 mm and a uniformity coefficient of from 1.3 to 1.7 is now most frequently specified where the water receives proper pretreatment.

Experience has also shown that efficiency of filtration is not dependent upon the filtering media. The principal material other than sand is "Anthrafilt," a crushed and graded anthracite coal. Its use is believed justified where it is available at a cost comparable to that of good filter sand. Being lighter in weight, Anthrafilt can be expanded and washed at lower rates of backwash than sand, a factor of some importance in old plants whose hydraulic design does not permit high-rate backwash. In general any insoluble granular material of proper size and gradation can filter water.

There is little difference in the operating results between most of the patented filter underdrains on the market and conventional pipe lateral systems when designed according to the hydraulic criteria developed by H. N. Jenks, M. ASCE. Therefore the type to use should be determined from an economic evaluation of all factors at the location under study. The availability of materials and the contractor's or owner's preference often determine the one chosen. With pipe lateral underdrains, 24 in. of graded gravel is ordinarily used. This is usually reduced to about 14 in. with block bottoms, which themselves occupy about 10 in. Porous "filtros plate" bottoms have been installed at a few places but have not been adopted for the larger municipal plants.

Sufficient backwash water should be provided to give a sand expansion of at least 50 percent, and a rate of rise of 24 to 36 in. per min, depending on the temperature of the water.

Surface wash facilities are now included in most filter installations, and are essential for all turbid waters. Where surface wash is available, less sand expansion is required and the total wash rate, both for back and surface wash, rarely exceeds 24 in. per min, of which one-eighth to one-fifth is for surface wash. Whether to use a fixed-type of surface wash or a movable type is again a matter of overall comparative cost. Either system, if properly designed and operated, will give satisfactory results. The fixed type has many variations—from the horizontal perforated pipe grid installed at Milwaukee, the Baylis type of vertical nozzles installed at Chicago (both operating at low wash-water head), to the Lovejoy type at Louisville with the pipes on 7-ft centers and operating at 80-psi pressure.

In a water treatment plant, hydraulically operated valves generally give less trouble than electrically operated valves. The high humidity around a water plant tends to cause a more rapid breakdown of electrical control equipment.

Feasibility of lime reclamation

No part of the problem of water softening has been more troublesome than the disposal of the large volume of lime sludge. So far no process for reclaiming lime has been thoroughly proven to be economical for a small plant. Sludge from small plants is usually pumped to fill low ground, abandoned quarries or gravel pits, or where other means are lacking, to lagoons. For plants above about 20- to 40-mgd capacity, depending on the hardness of the water treated, lime reclamation has not only been found practicable, but also economically desirable—except at locations where lime costs are low.

Data from the small number of plants at present reclaiming lime indicate that the reclaimed lime, having an "available lime" content of a least 90 percent, will cost $8 to $11 per ton, including all operating costs, interest and depreciation. The costs will vary, depending on the type of plant, capacity, load factor, fuel, power and labor costs. The economic feasibility of lime reclamation must therefore be determined on the basis of such costs as compared with the cost of commercial lime plus that of sludge disposal.

In Miami, Fla., where the first large installation was made in the United States, an 80-ton-per-day lime reclamation plant costing nearly $800,000 paid for itself in about four years in savings in the cost of lime produced and used in the treatment process. This was in conjunction with a 60-mgd water softening plant. This was accomplished in Miami, where the hardness comes largely from calcium bicarbonates, and where the competitive cost of purchased lime is high. However a sludge which also contains magnesium salts has been satisfactorily recalcined in continuous operations by the use of a centrifuge type of dewatering equipment. With this type of equipment the potential buildup of these undesirable salts can be greatly reduced or eliminated.

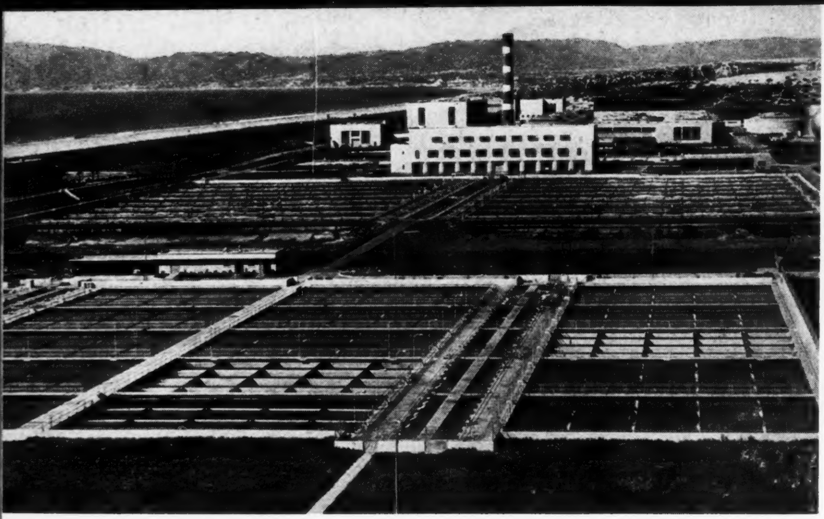
The calciner at Miami is a rotary kiln, which is only suitable for relatively large installations. A new Dorr Company FlusSolids calciner pilot plant, with a capacity of 6 tons per day, has been tested at length at Lansing, Mich. As a result a 30-ton-per-day installation was recently completed and is about to be put in operation. This type of calciner may be adaptable to smaller installations than the rotary kiln. There is a great need for such equipment, not only to reduce the cost of water treatment in favorable locations, but also to eliminate or reduce the continual problem of sludge disposal with which every lime softening plant is faced.

Conclusions are summarized in a box near the beginning of the article.

Progress continues

Now that water treatment has reached so high a stage of development, there is some indication that treatment directed toward turning out a highly polished water may in some cases be adversely affecting the carrying capacity of the water mains, the value of which constitutes about two-thirds that of the total water works.

Progress in water treatment has been achieved, and will continue to be achieved, through the combined efforts of designing engineers, filter operators, chemists, and research workers.



Trickling filters and activated-sludge process remain the two standard methods of oxidizing sewage. Photo at left shows mammoth Hyperion sewage treatment plant at Los Angeles, Calif., where 32 aeration tanks are used in activated-sludge process for average flow of 245 mgd. Trickling-filter plant at Liberty, N.Y., is seen at right, with its two 80-ft high-rate trickling filters, each 3 ft deep, in foreground. Use of trickling filters has greatly increased with development of higher loadings.

Research points way to more efficient

C. E. KEEFER, M. ASCE

Since 1930, when Civil Engineering was first published, there has been a steady advance in the art of sewage treatment. This advance has been accompanied by a marked increase in knowledge of the fundamentals of the various treatment processes. During this period a great many sewage plants, both large and small, have been put in service in this country. During the depression, construction was accelerated to improve economic conditions, but during the war that followed a minimum of work was done. Since 1945 many new works have been completed and old ones remodeled and enlarged.

During the past quarter of a century there has been a change in the character of raw sewage in many cities. Two factors are primarily responsible for this change. The first is the ever increasing use of detergents, with a corresponding decrease in the use of soap. And the second is the introduction of ground garbage into sewage as a result of the use of garbage grinders in homes and restaurants. The concentration of detergents in municipal sewages will probably increase, and it is too early to predict what effect this increased concentration will have on sewage-plant efficiencies and what steps may have to be taken to counteract their effects, if they should become detrimental. Sanitary engineers both in this country and abroad are well aware of the situation and are continuing their researches.

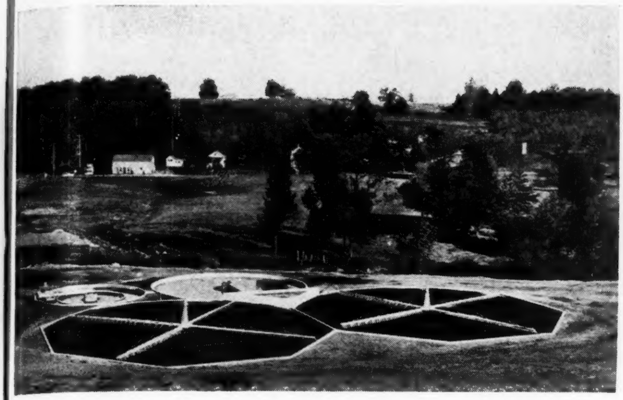
The problem of handling the increased organic load resulting from ground garbage, though simple of solution, requires an increase in the size of such treatment units as sludge digesters, vacuum filters, and other sludge treatment and handling facilities. The substitution of the domestic garbage grinder for the garbage pail has been a notable step forward in municipal sanitation without presenting any unusual or difficult problems to the designer or operator of the sewage treatment works.

There has been no marked advance during the past 25 years in the design of the various preliminary treatment units used at sewage plants. During this period the mechanization associated with preliminary treatment has become firmly established. The use of mechanically cleaned screens, grit chambers and preliminary settling tanks, the adoption of comminutors, and the grinding of screenings, have become the rule rather than the exception. A variety of sludge cleaning mechanisms for settling tanks are available. The process of sedimentation has become better understood through the studies of Thomas R. Camp, M. ASCE, and his associates. The work of Richard H. Gould, M. ASCE, in New York, N.Y., has indicated the possibility of improving sedimentation efficiencies.

Great room for improvement

There is great room for improvement in the design of sedimentation tanks. Better means should be devised to reduce the velocity of the incoming sewage to maintain a uniform velocity through all parts of the tank, and to draw off the effluent with as little disturbance as possible to the tank contents. The design of many tank cleaning mechanisms, with their numerous moving parts exposed to the corrosive and erosive action of sewage, should be improved to prolong their life and to insure uninterrupted operation.

In the mid-thirties there was a renewed interest in chemical precipitation. A few of the installations where this method of sewage treatment was adopted were at Coney Island in New York and Dearborn, Mich. Perhaps the outstanding example of the use of chemical precipitation is the plant operated by the Bethlehem Steel Co. at the Back River sewage works, Baltimore, Md. At this plant about 45 mgd of humus tank effluent is treated with approximately 4 grains of alum per gal of sewage; the sewage is flocculated and settled; and the purified effluent is



Use of vacuum filters at both large and small plants has become standard practice for dewatering raw, digested, or activated sludge. Vacuum filter installation at Chicago's West-Southwest sewage treatment plant, shown above, has 98 Oliver filters with 570 sq ft of filter area for each. Below, flash dryer for sewage treatment plant in Springfield, Mass., is pictured. At this plant, digested sludge, after dewatering on vacuum filters, is flash dried to 5 or 6 percent moisture. Market for sale of dried sludge as fertilizer is uncertain in most areas.

SEWAGE TREATMENT

Deputy Sewerage Engineer, Bureau of Sewers, Baltimore, Md.

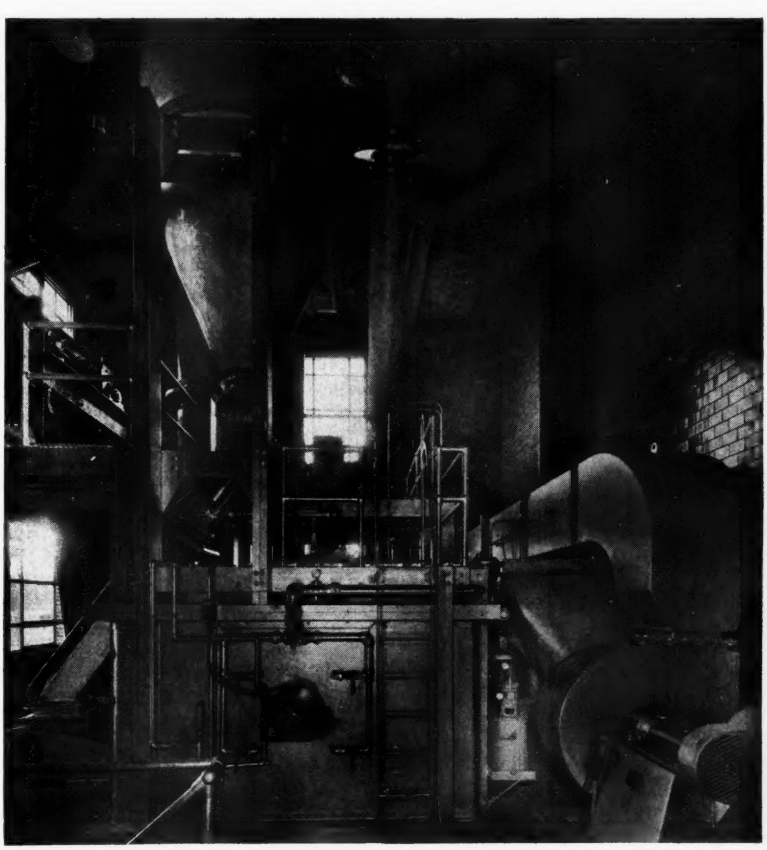
used by the company for industrial purposes.

Chemical precipitation was considered to give treatment intermediate between that obtained by plain sedimentation and trickling filters. For that reason it had a number of advocates. However the process has two disadvantages. It is costly and considerable quantities of sludge must be handled and disposed of. Consequently, chemical precipitation is little used today.

Two standard oxidation processes

Trickling filters and the activated-sludge process remain the two standard methods of oxidizing sewage. As a result of the investigation and study of high-rate filtration in this country and of alternating double filtration in England since the mid-thirties, the use of trickling filters has greatly increased. Loadings unheard of 25 years ago are now extensively used.

The activated-sludge process still remains the standard method of treating large sewage flows. Many large activated-sludge plants, serving such cities as Chicago, New York, Boston, and Los Angeles, have been put in successful service in recent years. New aeration-tank designs using step aeration, tapered aeration, and modified aeration have been adopted. Much shorter aeration periods are now used,



especially where the highest degree of treatment is not required.

Much remains to be learned about the physiochemical and biochemical reactions involved in the activated-sludge process. No reliable method has been found to prevent or remedy sludge bulking. The process is inefficient in that only a small percentage of the power required to introduce oxygen into the sewage is actually responsible for the biochemical reactions. Another disadvantage of the process has been the high water content of the sludge produced. Wilbur N. Torpey, M. ASCE, in New York, reports that by mixing primary and activated sludges he has obtained sludge averaging 11.2 percent solids for an entire year. If his findings are dupplicated in other places, an important advance will have been made in handling activated sludge.

Prior to 1930, Willem Rudolfs, Gorden M. Fair, Members ASCE, and others, established the general principles of sludge digestion. Immediately following their early investigations a few sewage plants were constructed with facilities for heating digesters and for collecting and utilizing the gas. With temperatures maintained between about 85 and 100 deg F, it was possible to obtain a digested sludge in about 30 days. Since 1930, separate sludge digestion has become a well established method of sludge treatment at both large and small sewage-treatment plants. Some of the larger installations may be found at Washington, D.C., New York, N.Y., Los Angeles, Calif., and Cleveland, Ohio.

Since 1930 efforts to speed up sludge digestion have continued. A M Rawn, M. ASCE, reported that by using a four-stage digester he could obtain digested sludge within 10 days. Studies conducted by Rudolfs, H. Heunkelekian and others, revealed that by digesting sludge at higher temperatures in the thermophilic zone, digestion was possible within less than 10 days. Although thermophilic digestion is possible it has been used only sporadically. A. J. Fischer, M. ASCE, reported that the sludge resulting therefrom was quite odorous and difficult to handle. More recently P. F. Morgan and Wilbur N. Torpey, Members ASCE, have reported obtaining satisfactory digestion within periods considerably less than 10 days.

One of the difficult problems associated with sludge digestion has been the formation of scum. Ralph E. Fuhrman, M. ASCE, has been able to cope satisfactorily with this problem by introducing sludge gas into digesters below the scum layer.

During the early years of sludge-digester design, heating was usually accomplished by pipe coils suspended inside the tanks. More recently there has been a trend toward the use of external heat exchangers. A novel method of heating digesters that has been practiced in Baltimore and Philadelphia is by submerged gas burners.

Generation of power by using sludge gas in internal combustion engines is standard practice. Use of dual-fuel engines, capable of burning either gas or oil, has ensured continuity of service with this type of equipment.

Sludge dewatering and disposal

Before 1930 there were relatively few plants in which vacuum filters were used to dewater sewage sludge, and activated sludge was the only material dewatered. In 1931-1932 experiments conducted in Baltimore, Md., indicated that digested sludge could be dewatered at costs comparable with those for dewatering on sludge drying beds. Furthermore, investigations by A. L. Genter, M. ASCE, at the Baltimore plant showed that filtration costs could be materially reduced by washing out a considerable percentage of the bicarbonates in digested sludge, thereby reducing the amount of coagulant required. As a result of his studies, the elutriation process has been adopted in a number of cities such as San Francisco, Calif., Washington, D. C., and Winnipeg, Canada.

Since the work done by F. W. Mohlman and J. R. Palmer in Chicago in 1928, no chemical better than ferric chloride has been found to coagulate sludge. Consequently this chemical is widely used where sludge is dewatered on vacuum filters. Chlorinated copperas was used for many years in Baltimore, one reason being that ferrous sulfate, a byproduct of the pigment industry, was obtained locally at a very low price. At Detroit, Mich., where raw sludge is dewatered, filtration economies are effected by using waste lime slurry instead of pebble lime in conjunction with ferric chloride as a coagulant.

Wool or cotton cloths are the materials most widely used on vacuum filters. Spring-wound filters have been adopted at a few installations. Although they are more costly than conventional wool-cloth filters, it is claimed that their capacity is greater and that the stainless-steel springs have a much longer life than wool cloths. The use of vacuum filters, both at large and small plants, for dewatering raw, digested or activated-sludge, has become standard practice.

The operation and treatment results obtained at the sewage plant now being built to serve Pittsburgh, Pa., and a number of adjacent municipalities, will be studied with considerable interest. At this plant it is planned to concentrate the preheated raw sludge in 10 tanks by flotation for 5 days to a moisture content of about 18 percent and dispose of the remainder by incineration.

Sanitary engineers are realizing more than ever the need of solving the problem of the final disposal of sludge. Therefore many plants are now being provided with facilities for either heat drying the sludge to a moisture content of 5 to 10 percent and disposing of it for fertilizing purposes, or by incineration. Of all the cities where sludge is dried and disposed of as a fertilizer, Milwaukee, Wis., has had the longest record. Even though the sludge is of high quality, Ray D. Leary claims that during the past few years the process has not been self-supporting. At Washington, D.C., where the sludge can be either heat dried or incinerated, it is reported that the latter method of disposal will be used, one reason being that the sludge is of poor quality.

With the increasing demand for water by industry and the great need of it for irrigation in arid sections of the country, it is believed that the utilization of sewage effluents will continue to increase. The most striking example of such utilization is that by the Bethlehem Steel Co. in Baltimore, Md. At present this company is using an average of 65 mgd of highly purified effluent for industrial purposes. It has just completed the construction of an additional 96-in. steel pipeline with a capacity of 150 mgd from the Back River sewage-treatment works to the plant. With the completion of this pipeline, the plant will be able to secure approximately 195 mgd of effluent for industrial use.

It is estimated that $14.6 billion will be needed within the next 10 years to meet the demand for building and enlarging sewage plants in this country. If this money is to be spent to the best advantage, extensive research will be needed. Such research should deal with sewage-treatment problems on a national, state, municipal and university level. Just as industry has found that it pays to continue research studies of new and current problems, so municipalities will find it profitable to conduct research relating to sewage treatment so that less expensive and more efficient plants can be built. Many problems dealing with sewage sedimentation, trickling-filter performance, the activated-sludge process, sludge digestion, and sludge filtration remain to be solved. Studies both of a theoretical and a practical nature should be continued to throw light on the many unsolved problems.

(*Continued on page 160*)

Pretensioning wires in test beam curved by simple device

MERRILL E. CRISSEY, Instructor in Civil Engineering
MURRAY I. MANTELL, A.M. ASCE, Chairman, Civil Engineering Department; University of Miami, Coral Gables, Fla.

A new technique for the prestressing of concrete flexural members has recently been developed at the University of Miami. Pretensioned prestressing wires are curved by exterior forces so that their position in the member compensates for the dead-load stresses. Although "curved-wire" prestressing is now common with post-tensioned systems, it's application to pretensioned systems is believed to be a very recent development.

An investigation was begun early in 1954 to determine what practical means might be employed to curve pretensioned tendons. Several methods were found to be economically feasible. A test beam was then designed, using one of the methods, and constructed on the prestressing bed at the University of Miami. A section and elevation of the test beam are shown in Fig. 1.

The method used to curve the wires in the test beam was as follows. All the wires were tensioned straight at their proper location at the ends of the beam. A fixture (Fig. 2) was placed at midspan in which slots engaged the wires. Through this fixture was passed a tapered rod with a shoulder at the fixture and threads at the bottom. The threaded rod was screwed into a nut plate which bore on a pair of channels cast into the stressing bed and anchored by deadmen into the earth. The tensioned wires were thus pulled down to the proper location at midspan to compensate for the beam weight. The total stress in the wires was determined from their original extension plus the extension caused by the curving of the wires. More curving points would have allowed a better approximation of the desired shape of the curved wires.

After the pretensioned wires were curved, the beam was cast and cured. When the concrete strength reached two-thirds of the design strength of 5,000 psi, the tapered bolt was removed from the beam and the prestressing wires released, leaving the curved pretensioned wires in place.

The beam was tested by loading with 8 × 8 × 16-in. concrete blocks. Deflection at midspan and slip of the prestressing wires at the ends were re-

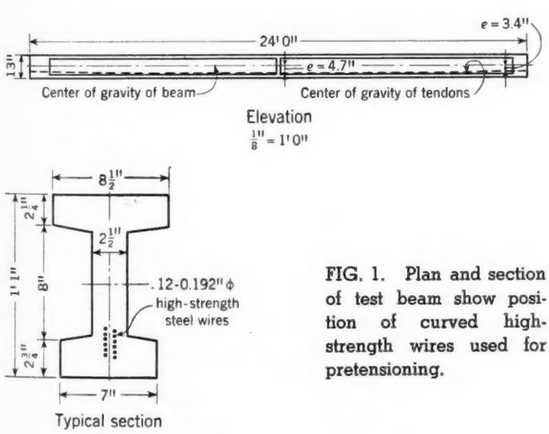


FIG. 1. Plan and section of test beam show position of curved high-strength wires used for pretensioning.

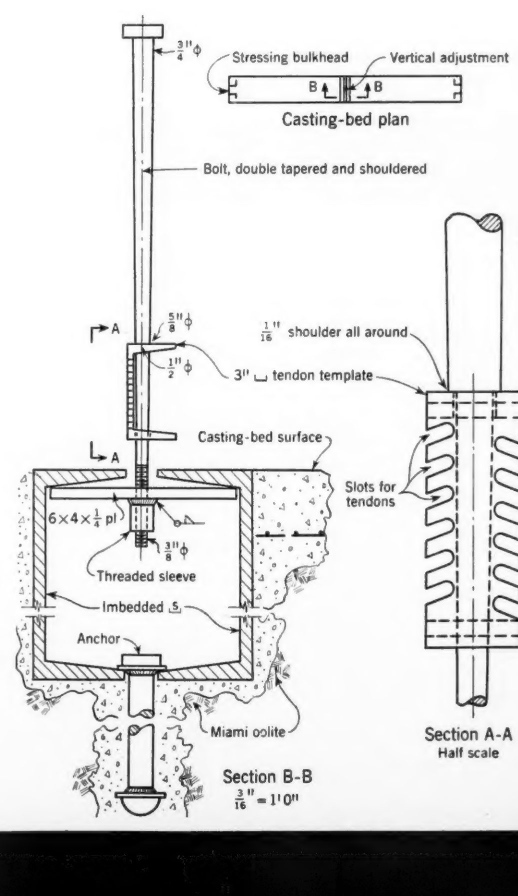
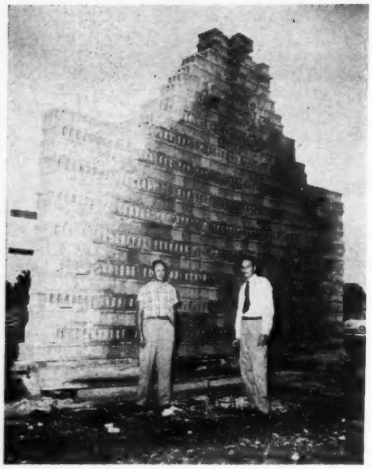


FIG. 2. To curve pretensioning wires, fixture was placed at midspan in which slots engaged the wires. Through this fixture was passed tapered rod with shoulder at fixture and threads at bottom. Tensioned wires were thus pulled down to proper location at midspan to compensate for beam weight.

TABLE I. Comparison of prestressed test joist with conventional precast joist of similar load-carrying capacity

Factors	Test Beam with Curved Wires	Conventional Concrete Beam
Depth of member	13 in.	16 in.
Concrete area	54 sq in.	80 sq in.
Steel area	0.36 sq in.	1.80 sq in.
Weight per foot	56 lb	85 lb
Span	24 ft	24 ft
Working concrete stress	2,000 psi	1,688 psi
Working steel stress	120,000 psi	20,000 psi
Calculated design load	320 lb	316 lb per ft
Calculated cracking load	490 lb per ft	...
Calculated ultimate load	840 lb per ft	...
Calculated design load deflection	0.47 in.	0.58 in.



Beam was tested by loading with concrete blocks. Deflection at midspan and slip of prestressing wires at ends were recorded after each course of blocks was placed. No slip was recorded by $^1/_{10,000}$-in. dial indicator even at maximum load. Authors are standing in front of test beam.

corded after each course of blocks was placed. No noticeable slip of the wires was recorded by the $^1/_{10,000}$-in. dial indicator, even at maximum load. Load-deflection curves showed the first crack as predicted, and the expected ultimate was exceeded.

Tables I and II indicate the advantages of curved-wire pretensioning members over straight-wire pretensioning members as well as over conventional concrete members.

It is believed that pretensioned curved-wire prestressing will be a major step leading to the economical and versatile use of prestressing in an ever-increasing variety of structures. The present practical limit of post-tensioned wires to a maximum of about three continuous spans, because of the frictional resistance developed, can be extended to almost an unlimited number of continuous spans by the use of a curved pretensioned system. It now seems feasible to design special reusable beam form soffits which may make both precast and poured-in-place prestressing economically competitive with conventional reinforced concrete, even on the smallest of buildings.

TABLE II. Performance of test beam compared with beam of similar size and reinforcement having straight pretensioned wires

Load	Curved-Wire Joist, lb per ft	Straight-Wire Joist, lb per ft
Calculated design load	320	260
Calculated cracking load	490	430
Calculated ultimate load	840	725

The research staff, in addition to the authors, included Edward Heyer, civil engineering faculty, and Richard Reynolds, senior civil engineering student. The work was made possible by a research grant from the I. E. Schilling Company, Inc., of Miami, Fla.

THE READERS WRITE

Constant facilitates solution for circular arc and area of segment

To the Editor: The simple solution for finding the circular arc and area of a segment, as given by John L. Nagle, M. ASCE (June issue, p. 61) and in the discussion by Prof. T. F. Hickerson, M. ASCE (August issue, p. 65) is much more easily applied when a constant, K, is employed. Let,

K = arc length, with radius 1; and central angle, 1 min. Then

$$K = \frac{2\pi}{21,600} = 0.000\,290\,888\,2$$

(log: 6.463 7261 − 10)

With the central angle, θ, measured in minutes,

$$\text{Arc } s = R\,\theta\,K \qquad (1)$$

Area of segment A

$$= \frac{R^2}{2}(\theta K - \sin\theta) \qquad (2)$$

$$= \frac{R}{2}(s - R\sin\theta) \qquad (3)$$

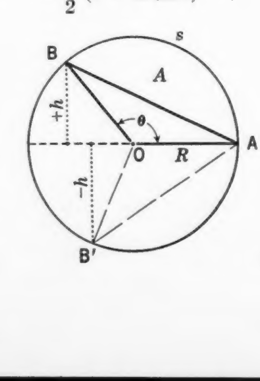


Fig. 1

The accompanying Fig. 1 better illustrates the true altitude, h, and base, R, of triangle AOB, as used in Professor Hickerson's Eq. (b). It also points up the negative value of $\sin\theta$, when point B falls in either the third or fourth quadrant.

The statement,

"A = area of sector AOB − area of triangle AOB"

is true only when B falls in the first or second quadrant. When the central angle is greater than 180 deg, the area of the triangle is added, rather than subtracted.

Francis Bates, M. ASCE

Alhambra, Calif.

Recounts construction of Mexico City's Palace

TO THE EDITOR: The article by Messrs. Thornley, Spencer and Albin, in the June issue, entitled "Mexico's Palace of Fine Arts Settles 10 Ft," is especially interesting to me since I was resident engineer and chief assistant to the architect, Adamo Boari, from 1907 to 1912.

Adamo Boari, an Italian-American architect who had been for many years connected with Burnham of Chicago, won the competition for the design and construction of the National Theater (now known as the Palacio de Bellas Artes) somewhere about 1903–1904. He was already known to the Mexican Government as the architect on the main Post Office Building in Mexico City. The Secretary of Public Works, who admired him very much, named him architect-director of the construction of the National Theater and allowed him to carry on independently, under a special appropriation, answering only to a Mr. Montiel, then Subsecretary of Public Works.

Adamo Boari was no engineer; he was a splendid artist with no idea whatsoever of practical engineering. He would say, "I don't need an engineer; if the structure is pleasant to my eye it is structurally sound." Notwithstanding this, for the structural design he secured the services of a good New York engineer, well experienced in theater construction, by the name of Burkmeyer. I never knew what assumptions he made for the foundation design and why such heavy grillages and concrete mat were used on so poor a subsoil.

I joined Boari's staff about the middle of 1907 when I was barely 20 years old, freshly out of school. My job was to work out construction details, supervise construction, and act as resident engineer. Toward the end of 1907, or the beginning of 1908, the erection of the steel frame was completed by Milliken Bros., the steel contractors, and erection of concrete curtain walls started. Before long I initiated a leveling control system, using for a bench mark the capped casing of a dry artesian well which, I understood, went to bedrock.

Several old Spanish buildings had to be razed to prepare the site. These had been built on piles, which surprisingly enough were removed and all voids filled with concrete to the under side of the proposed structural mat. This concrete is what the authors call "the first lift."

My leveling of the steel column bases revealed some of the columns to be as much as a foot out of level. This of course astounded me, as such a discrepancy seemed impossible. When I told the sad news to Boari he could not at first believe it. Then he blamed my youth and inexperience, and almost discharged me for incompetence, but finally government engineers were called in to check, and not only did they confirm my statements but recommended that I be included on subsequent studies to determine what was really happening.

I ran levels daily for months and as a result a more startling blow struck Boari—the structure was settling at the rate of about 40 mm per month. This increased to a maximum of 42 or 43 mm, and it was not settling evenly. The northwest corner was settling at a faster rate.

Meanwhile curtain walls and concrete floors were going up and the foundations for the Pergola were completed. This Pergola was placed as an architectural motif at the eastern end of Alameda Park, some 300 ft away from the theater, and unlike the massive theater foundations, the Pergola foundation consisted of a very light reinforced concrete slab, bearing on the subsoil less than 10 percent of what the theater mat did.

As the daily leveling was continued, another startling thing came to our attention. While the theater building was settling at the rate of about 40 mm a month, the Pergola slab was rising about 10 mm per month. Boari would say, "Incredible!"

After these facts were ascertained, the problem continued to be what to do next. Boari by this time had come to rely on my judgment more and more and very often would say, "If you were in my place what would you do?" And I would say "You have started wrong; the weight of the foundations alone bears on the subsoil more than it can support. Not much more than the steel frame is up. Why don't you tear it down, redesign the foundations, considering the use of piles, and start over again? Believe me it is the best way out."

"How can I do such a thing?" he would retort. "How can I demolish what I have been putting up for such a long time? What will the people say? What will the President think? What will happen to my prestige, my reputation?"

And I would cruelly answer, "What will your reputation be fifty years from now when only the dome will be sticking out of the ground?"

Boari would not consider the dismantling of the frame and, wondering what the next best solution would be, he requested Mr. Montiel of the Department of Public Works to name a committee of engineers to study the problem further and make final recommendations.

A remedy suggested

Some time elapsed before any solution was suggested, and even though some of the committee members agreed with my recommendation to dismantle, the consensus was to place an interlocking steel cofferdam around the periphery of the building, 25 ft deep and 25 ft away from the face of the outer walls, and to stabilize the soil between the steel piling and the foundations of the building, approximately as shown in Fig. 1 of the authors' article.

This would serve two purposes. First, the cofferdam would resist the horizontal pressure caused by the settling of the building in a semi-liquid medium. At that time the water table was at the grass roots and test holes revealed a fine volcanic ash to a considerable depth. This force, however small, was not negligible, as substantiated by the rising of the Pergola foundations. Second, the stabilization or consolidation of the area beyond the face of the mat to the cofferdam would increase the bearing area of the building foundation about 16 percent and thereby reduce the unit pressure on the subsoil.

This stabilization was effected by injecting 1 : 2 cement-sand grout, which according to laboratory tests would stabilize the volcanic ash quite effectively. About 20,000 sacks of cement were used and 40 to 50 thousand cu ft of sand. The weight put on the soil beyond the periphery of the footings amounted to not over 40 psf.

Construction of the building was stopped in 1912–1913. By that time the remedial work had been completed and the settlement reduced from 42 mm per month to 11 mm. And lo and behold, the rising of the Pergola was also reduced to a minimum. The Palace continued to settle at about the same rate, which is equivalent to 132 mm per year, or 5.2 in. According to the authors of the article, that was about the rate when the report was written in 1950, or 38 years later.

In 1909-1910, several cracks developed at the proscenium arch and at the lateral porticoes. The uneven settlement of the porticoes developed vertical cracks at the face of the building wall; these cracks in 1911–1912, the year I left, were so large that a person could crawl through them.

Even though the settling of the big building had been reduced substantially, Boari, with the vision of an artist, could see his brain-child sinking in the slushy soil of Lake Texcoco. This was too much for his gentle nature. He worried himself sick. Later he fell and broke his leg—the beginning of the end. Soon after he went to his native land for a rest cure, eternal rest was his reward.

In the early years of the century, neither engineers nor architects knew much about soil stabilization. For example, in spite of the evidence of settling of the Palace, the subsoil under the Ministry of Public Works Building just around the corner was solidified merely by placing a deep layer of crushed rock on it. This building subsequently settled quite a bit. Through a study of the settlement of these and other structures, much has since been learned about this problem.

CAMILLE C. ROSSI
Asst. Director of Engineering
U.S. Atomic Energy Commission
Oakland, Calif.

By 1911 construction of Palace of Fine Arts had progressed to this stage. Settlement continued and cracks appeared.

SOCIETY NEWS

New ASCE Officers to Be Inducted at Annual Convention

Biographies of Ten New Officers

Enoch R. Needles

Taking office in October as 87th President of the Society is Enoch R. Needles, a noted bridge engineer and member of the New York and Kansas City firm of Howard, Needles, Tammen & Bergendoff. Becoming an Associate Member of ASCE in 1922 and Member in 1925, Mr. Needles was Director from 1937 to 1939, and in October he will complete a two-year term as Vice-President from Zone I. He has also served the Society on many committee assignments, and has been president of the Metropolitan Section.

Born in Missouri and a graduate of the Missouri School of Mines and Metallurgy in 1914, Mr. Needles had his early engineering experience in the Middle West, with emphasis on the design and construction of bridges. He opened an office for his firm in New York in 1922, and has since made the city his business headquarters. In 1928 he became a partner in the firm of Ash, Howard, Needles & Tammen, the firm name being changed to Howard, Needles, Tammen & Bergendoff in 1940. During the period 1928–1940, the firm was especially active in bridge work. Among its major structures at the time were the Harlem River and Bronx Kills portions of the Triborough Bridge in New York and a notable group of four Mississippi River Bridges.

In 1941 Mr. Needles served as resident partner for his firm on the Southwestern Proving Ground at Hope, Ark., and in the following year was resident partner on the Bluebonnet Ordnance Plant near Waco, Tex. In December 1942 he entered the Corps of Engineers as lieutenant colonel and was promoted to colonel in July 1944. During this period he was assigned to the Office of the Chief of Engineers in Washington, D.C. When he left the Army at the end of the war he received the Legion of Merit for his services.

Beginning in 1946, Mr. Needles gave particular attention to the design and construction of the Delaware Memorial Bridge near Wilmington, Del. At the same time he became prominently associated with the financing, design, and construction of many of the major expressways and turnpikes that sprang into popularity immediately after World War II. He was personally connected with the original Maine Turnpike, the first modern turnpike to be planned and built on a fully self-supporting basis. Beginning in 1949, he was active in the financing, design, and construction of the New Jersey Turnpike. His connection with the project has continued to the present extension to connect the original turnpike in the vicinity of Newark Airport with the Holland Tunnel under the Hudson River. This extension is approximately eight miles long and is extremely difficult construction as reflected in its cost of approximately $10,000,000 a mile. In addition to the foregoing turnpike projects, Mr. Needles' firm has been prominently identified with turnpikes in ten other states.

ENOCH R. NEEDLES
President-elect of ASCE

In his professional work Mr. Needles has always cherished the close association with his partners that their engineering organization has afforded for so many years, and the continued success of the organization has always been his primary concern.

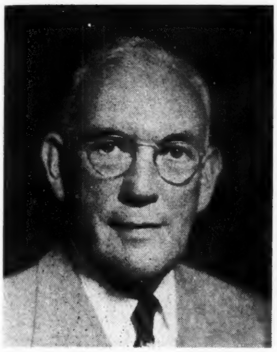
In 1946 Mr. Needles served as president of the American Institute of Consulting Engineers, and in 1949 and 1950 he was president of the American Road Builders Association. His other engineering society affiliations include the Engineers Council for Professional Development, the Society of American Military Engineers, the American Concrete Institute, the National Society of Professional Engineers, and the Princeton University Civil Engineering Advisory Council. In 1937 he received the honorary degree of doctor of engineering from his alma mater, with which he has always maintained close personal ties.

For many years Mr. Needles has made his home in Summit, N.J., where he has been active in civic affairs. He is a trustee of the Kent Place school and a former member of the Summit Zoning Board. He has six children and thirteen grandchildren.

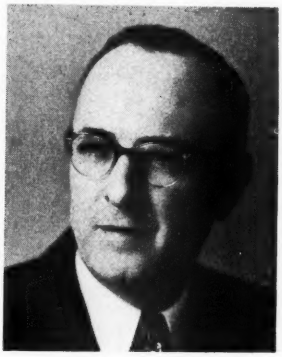
Frank A. Marston

Frank A. Marston, newly elected Vice-President for Zone I, has been a partner in the Boston engineering firm of Metcalf & Eddy for the past 35 years, engaged on projects involving sewerage works, water works, refuse-disposal plants, and drainage problems. Since 1937 he has been consulting sanitary engineer on the staff of the chief engineer of the Board of Water Supply of the City of New York. Major projects with which he has been connected include a sewage-treatment plant, large diversion sewers, and investigation and report on a sewerage system, all for the District of Columbia; sewers and a sewage treatment plant for Louisville, Ky.; reconstruction of water-pumping stations and a new mechanical water-filter plant for Wilmington, Del.; and many other projects in the sanitary engineering field. He is a graduate of Worcester Polytechnic Institute, class of 1907.

Mr. Marston became a Junior Member of ASCE in 1910, Associate Member in



FRANK A. MARSTON
Vice-President, Zone I



GLENN W. HOLCOMB
Vice-President, Zone IV

JOHN P. RILEY
Director, District 1

1917, Member in 1920, and is now a Life Member. He has been a member of the Committee on Engineers' Code; member of the Committee on Professional Fees, of which he was chairman for a year; and member of the executive committee of the Soil Mechanics and Foundations Division for eight years, and chairman for four years. He was a member of the Task Committee on Technical Division Structure for five years, and member of the Task Committee on Certification of Sanitary Engineers. While Director of the Society from 1952 to 1954, he served on the Committee on Publications (chairman one year), the Committee on Professional Conduct, and the Committee on Budget.

A life member of the Boston Society of Civil Engineers, Mr. Marston has served it as president. He is also a life member of the New England Water Works Association and the American Water Works Association, and a member of other technical societies.

Glenn W. Holcomb

Well known as an engineering educator, Glenn W. Holcomb, new ASCE Vice-President of Zone IV, is chairman of the Department of Civil Engineering at Oregon State College, Corvallis. A civil engineering graduate of the University of Michigan in 1919, he received his M.S. in education from Oregon State College in 1931. In 1917 and 1918 he was in the Engineers Reserve Corps of the Army, serving this time at the University of Michigan, part of the period as instructor in surveying and mapping. He taught one year at Michigan following graduation.

He has been on the staff at Oregon State College since 1920, advancing through the various positions from instructor in civil engineering to chairman of the department. Professor Holcomb's work at Oregon State has included teaching extension courses for professional engineers throughout the state. He was director of Engineering Science, Management War Training (ESMWT) for Oregon during World War II. He has been active in arousing the interest of engineers and contractors in the value of education and research to their work.

He is author of various engineering manuals published by the OSC Cooperative Book Store and of engineering personnel and aptitude studies published in the *Journal of Applied Psychology* and the Journal of the Society for the Promotion of Engineering Education (now the ASEE).

Becoming an Associate Member of ASCE in 1928 and Member in 1951, Professor Holcomb has been active in the Oregon Section, which he served as vice-president in 1941 and 1942 and president in 1942 and 1943. He has just completed a term as Director of District 12. He is currently a member of the Board of Engineering Examiners for Oregon, the American Society for Engineering Education (in which he has been secretary and vice-chairman of the Northwest Section and chairman of the Structural Committee), the American Concrete Institute, Professional Engineers of Oregon, and American Association of University Professors. He has also been active in many municipal and civic groups, including the Corvallis City Council.

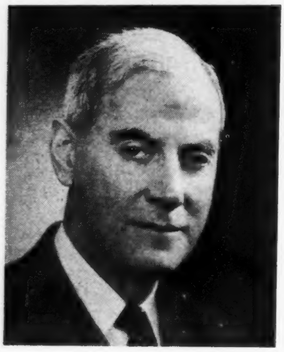
John P. Riley

The new ASCE Director for District 1 is John P. Riley, director of development for the New York City Housing Authority, with an impressive record of city housing and school building construction to his credit. Joining ASCE as Associate Member in 1929, Mr. Riley became a Member in 1940. He has been active for many years in the Metropolitan Section, which he has served as president. He is also an honorary member of the American Institute of Architects.

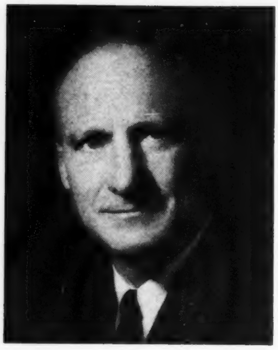
Born at Bellows Falls, Vt., Mr. Riley graduated from Cornell University in 1922, with the civil engineering degree. In his early career he was progress engineer on hydroelectric developments in New York and Pennsylvania and on paper-mill projects in Quebec. He then served as the construction engineer on the international vehicular tunnel between Detroit and Windsor, Canada, and later was field engineer on Upper Mississippi field-control work. From 1935 to 1937 he was assistant deputy administrator for the National Recovery Administration, and in 1937 and 1938 field engineer on studies and surveys for the original Pennsylvania Turnpike project between Harrisburg and Pittsburgh.

Mr. Riley's connection with New York City construction work goes back to 1938, when he became superintendent of the Queens Department of Housing and Building. From 1939 on he has been with the New York City Housing Authority, which he has served as construction deputy, chief engineer, and (from 1945 to 1951 and since 1953) director of development. With him at the engineering helm, the Authority has sponsored a construction program costing more than $700,000,000 and involving many special foundation problems. From March 1951 to March 1953 Mr. Riley was on leave of absence from the Authority to serve as coordinator of school construction for the New York City Board of Education. In the latter capacity he expedited the city's construction program (amounting to about $100,000,000 in the two-year period) and advised the Board of Education on procedures to improve the city's long-range handling of school construction.

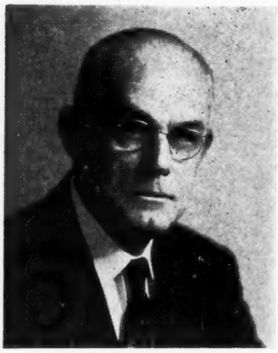
Recently Mr. Riley has also been serving as the civil engineer member of the Air Force's Projects Installation Committee, established to advise the Secretary of the Air Force on the reorganization of the Air Force's construction program.



CAREY H. BROWN
Director, District 3



MASON C. PRICHARD
Director, District 5



ROBERT H. SHERLOCK
Director, District 7

Carey H. Brown

Carey H. Brown, who will be new ASCE Director for District 3, is a noted industrial engineer. From 1945 until his recent retirement Mr. Brown was manager of engineering and manufacturing services of the Kodak Park Works of the Eastman Kodak Co., Rochester, N.Y. His home is at Scottsville, N.Y.

Mr. Brown was educated at the University of Chicago and the U.S. Military Academy at West Point, from which he graduated in 1910. In 1912 he graduated from the U.S. Army Engineering School. From 1910 to 1930 he was in the Corps of Engineers on assignments in Panama, Mexico, France, and the United States. Here he was assistant engineering commissioner for the District of Columbia (1919–1922); director of civil and military engineering for the Army Engineer School (1922–1925); and engineer of the National Capital Park and Planning Commission (1925–1929). He retired from the Army in 1930 with the rank of colonel. From 1930 to 1933 he was director of the Rochester Civic Improvement Association.

From 1934 until recently Mr. Brown was with Eastman. He was superintendent of engineering and maintenance for the Kodak Park Works from 1934 to 1942, and works manager for the Holston Ordnance Works of the Tennessee Eastman Corp. from 1942 to 1945.

A Member of ASCE since 1926, Mr. Brown has been active in the Rochester Section. He is also a member of the ASME and of Engineers Joint Council, serving as chairman of the Council's Engineering Manpower Commission in 1951 and 1952. Recently Mr. Brown served as a member of the Hoover Commission's Task Force on Water Resources and Power.

Mason C. Prichard

The new Director for ASCE District 5 is Mason C. Prichard, a Corps of Engineers veteran, now executive vice-president of the Foundation Co., New York. Mr. Prichard's home is at Rockville, Md.

A native of Alabama, Mr. Prichard was graduated from the University of Alabama in 1923. In 1928, after early work as resident engineer for the State Highway Department, office engineer for a Palm Beach, Fla., consulting firm, and private practice in Mobile, Mr. Prichard began a long connection with the U.S. Engineer Department. His assignments in the Department included five years as chief engineer on investigation and construction of the Florida Ship Canal; two years in charge of the flood control section in the office of the Chief of Engineers; and chief of operations, Caribbean Division, Washington, on construction of U.S. Army air bases in British possessions in the Atlantic and Caribbean. During World II he was called to duty as Colonel, General Staff Corps, and served for five years as chief of construction at Headquarters Army Service Forces, as chief of Construction Division of Army Forces, in the Western Pacific and in Washington on the staff of G-4. He returned to the U.S.E.D. in 1946 as special assistant on military construction to the Chief of Engineers, leaving in October 1954 for his present connection.

A Member of ASCE since 1926, Mr. Prichard has served on numerous committees at both national and local level. He was vice-president of the National Capital Section in 1953, and president in 1954. He represents the Society on the Joint ASCE-AGC committee and on the Construction Standards Board of the American Standards Association. His other affiliations include the Building Research Advisory Board, the National Academy of Sciences, the Washington Society of Engineers and the Cosmos Club.

Robert H. Sherlock

Robert H. Sherlock, new ASCE Director for District 7, has the distinction of being a holder of the Society's Norman Medal, which he won last year for a paper on "Variation of Wind Velocity and Gusts with Height." Professor of civil engineering at the University of Michigan, Ann Arbor, he has combined an active teaching career with outside consultation on design, investigations, appraisals, and reports.

He has made many researches for industries and agencies, including the National Electric Light Association, the Commonwealth Edison Co. of Chicago, the U.S. Navy Department, and the Stran-Steel Division of the Great Lakes Steel Corp. These studies have embraced wind gusts, the flow phenomena of smoke stacks, atmospheric turbulence, and wind velocities for the design of low buildings.

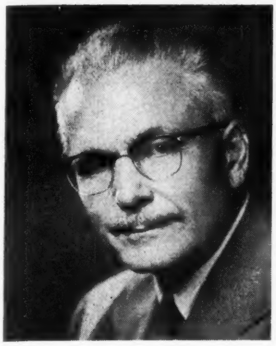
A civil engineering graduate of Purdue University, class of 1910, Professor Sherlock went to the University of Michigan in 1923 as assistant professor of civil engineering. He was associate professor from 1926 to 1933, and has been a full professor since 1933. For most of the period between 1910 and 1923 he was with the American Bridge Co. at Toledo, Ohio, on structural detailing, estimating, supervision of field work on bridge and dock repairs, etc. Professor Sherlock is the author of several reports and of many papers that have been published in the technical press here and abroad.

Professor Sherlock joined the Society as an Associate Member in 1925, becoming Member in 1935. He has been active in the Michigan Section.

R. Robinson Rowe

District 11 will send to the new Board of Direction R. Robinson Rowe, associate senior and supervising engineer in charge of research and special studies for the Bridge Department of the California Division of Highways, Sacramento. Mr. Rowe is already well known to readers of Civil Engineering as the talented N. G. Neare, whose column has met every deadline without editorial prompting since it was started in 1940.

Though long associated with the West



R. ROBINSON ROWE
Director, District 11

LOUIS E. RYDELL
Director, District 12

CLARENCE L. ECKEL
Director, District 16

Coast, Mr. Rowe is a New Englander, having been born at Spencer, Mass. He studied at Harvard University, graduating in 1916 with an A.B. cum laude in mathematics and in 1918 with an S.B. in architectural engineering. In 1918 he also received the B.S.C.E. degree from M.I.T. At Harvard he was managing editor of the *Harvard University Register*. After service in the Corps of Engineers in World War I, Mr. Rowe worked in Dayton, Ohio, and Salt Lake City, where he was in the U.S. Geological Survey. From 1926 to 1933 he was associated with Tom J. Allen, A.M. ASCE, in a consulting practice in San Diego.

From 1933 to 1937 Mr. Rowe was assistant and associate bridge construction engineer for the State of California on the San Francisco-Oakland Bay Bridge, and from 1937 to 1938 he was with the U.S. Forest Service at Juneau, Alaska. He has been with the Division of Highways at Sacramento since 1938. His work with the Division led to his coauthorship of *California Culvert Practice*, which was published in 1944 and revised in 1955.

Mr. Rowe became an Associate Member of ASCE in 1927 and Member in 1932. He is one of the few members to have been president of two Local Sections—San Diego and Sacramento. He has also been active in the San Francisco Section. In 1954 he was general chairman of the Pacific Southwest Conference of Local Sections, and he is currently chairman of the Engineering Council of Sacramento Valley. He has contributed to the ASCE TRANSACTIONS and to the proceedings of numerous other societies to which he belongs.

Louis E. Rydell

The new ASCE Director for District 12 is Louis E. Rydell, chief of the Planning and Reports Branch of the Walla Walla (Wash.) District of the Corps of Engineers, and a veteran in the field of river-basin planning.

A graduate of Oregon State College in 1925, with the B.S. degree in civil engineering, Mr. Rydell entered the field of river development and hydroelectric power in 1926. He was with the U.S. Geological Survey, and then (for five years) the City of Tacoma as designer on Cushman Dam No. 2 and hydroelectric development. From 1932 to 1934 he was engaged on project investigations for the Oregon State Hydroelectric Commission.

Since 1934 Mr. Rydell has been with the Corps of Engineers in the Portland, Los Angeles, and Walla Walla Districts, engaged in river-basin planning as it relates to flood control, power, and navigation. In the course of this work he was responsible for the project-planning phases of engineering studies in development of the 1937 Willamette Basin Comprehensive Plan, and for additional development of the basic plans for Detroit, Lookout Point, and other major dams and reservoirs in the Willamette Basin. Mr. Rydell was also responsible for hydroelectric power investigations in the southern half of the Columbia Basin, contributing to the Main Control Plan of 1948. In addition, he has directed project development planning in various river sub-basins and for such major projects as McNary Dam and The Dalles Dam.

Mr. Rydell's technical writings include a paper on "Determination of Outlet Control Requirements for Dams," presented before the Fourth Congress of Large Dams in New Delhi, India, in 1951, and coauthor of a paper on "Engineering Advancements at McNary Dam" presented before the ASCE New York Convention in October 1954.

His membership in the ASCE began in 1930, when he became an Associate Member and joined the Tacoma Section. He has also been in the Oregon and Columbia Sections. He was president of the Columbia Section and a director of the Northwest Regional Conference in 1953. Mr. Rydell is also a member of the Society of American Military Engineers, the Professional Engineers of Oregon, the United States Committee on Large Dams, and the International Association of Hydraulic Research. In 1951 he was one of the United States delegates to the International Hydraulic Engineering Conference and to the World Power Conference, held in India. In 1955 he was again a delegate, on his own initiative, to the Fifth Congress on Large Dams in Paris and, with Mrs. Rydell, participated in tours of river projects in France and Tunisia, North Africa. In June 1955 he was called by the State Department, at the request of the Irish Government, to advise on the control of River Shannon where disastrous floods occurred in late 1954.

Clarence L. Eckel

Clarence L. Eckel, dean of engineering at the University of Colorado and new ASCE Director for District 16, has lived in Colorado most of his life, though a native of Illinois. After his graduation from the University of Colorado in 1914, he became an instructor in civil engineering there. After serving as a captain in the 115 Engineers during World War I, he reentered the teaching profession as assistant professor, first at the University of Colorado and then at the University of Pennsylvania.

In 1923, he returned to the University of Colorado as professor of civil engineering. He became head of the department in 1926, and was appointed dean of the College of Engineering in 1943. Dean Eckel's summers and vacations have been devoted largely to engineering design and construction. He has also been structural

engineer and consultant on numerous university buildings.

Dean Eckel is one of the new Life Members of the Society, which he joined as Associate Member in 1920, becoming a Member in 1926. He has served on many ASCE committees and has been chairman of three—the Committee on Engineering Education, the Committee on Student Chapters, and the Committee on Registration. Since 1936 he has been ASCE representative for ECPD inspections. He has also been active in the Colorado Section, which he served as president in 1932.

Since 1942 Dean Eckel has been a member of the Colorado State Board of Registration for Professional Engineers and the Board of Examiners for Land Surveyors. He has been director and president of the National Council of State Boards of Engineering Examiners.

In recognition of Dean Eckel's efforts to establish a curriculum in architecture at the University of Colorado, and for rendering "the profession of architecture signal and valuable service," the Colorado Chapter of the American Institute of Architects has conferred its first honorary membership on him.

ASCE Prizes to Be Awarded During Convention

Winners of the Society's prizes and awards for papers adjudged the best in Volume 119 of Transactions (1954) were announced by the Board of Direction at its St. Louis meeting in June. The Construction Engineering Prize, unlike the others, goes to an especially meritorious Civil Engineering article. Presentation of the various awards—described in the 1955 Official Register—will be an important feature of the Wednesday morning business meeting during the Annual Convention in October.

Norman Medal

Karl Terzaghi, Hon. M. ASCE, professor of the practice of civil engineering at Harvard University and internationally famous authority in the field of soil mechanics, is the winner of the Norman Medal—the fourth time this oldest and most coveted of ASCE awards has gone to him. This year's prize-winning paper is on "Anchored Bulkheads." In addition to his teaching at Harvard, Professor Terzaghi is currently engaged as a consultant on earth dams by the Southern California Edison Co. and the British Columbia Electric Railway Co., and is a member of the Board of Consultants for the Saskatchewan Dam and the High Aswan Dam in Egypt. He is also preparing a book on engineering geology.

J. James R. Croes Medal

John S. McNown, M. ASCE, who will receive the J. James R. Croes Medal for a paper on "Mechanics of Manifold Flow," is a former winner of the J. C. Stevens Award and the Research Program Prize. An authority in the fields of mechanics and hydraulics, he taught both subjects at the State University of Iowa from 1943 to 1954, when he resigned to accept his present post as professor of engineering mechanics at the University of Michigan. Professor McNown recently spent a year at Grenoble, France, as Fulbright Research Scholar.

Thomas Fitch Rowland Prize

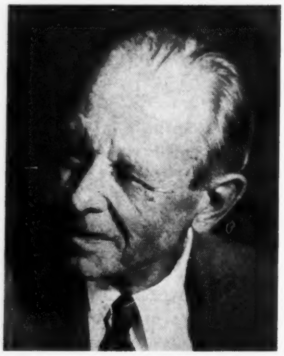
The Thomas Fitch Rowland Prize goes to Maurice N. Quade, M. ASCE, of New York City, for his paper on "Special Design Features of the Yorktown Bridge"—one of many important bridges for the design of which Mr. Quade has been responsible in his capacity as partner in the firm of Parsons, Brinckerhoff, Hall & Macdonald. Mr. Quade is a member of the executive committee of the Structural Division, and a former president of the Metropolitan Section.

James Laurie Prize

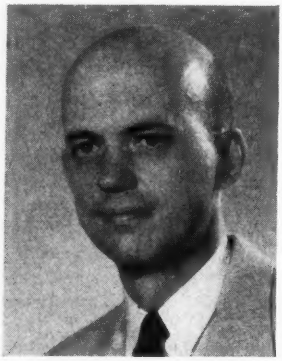
Joseph N. Bradley, M. ASCE, who will receive the James Laurie Prize for a paper on "Rating Curves for Flow Over Drum Gates," has served in many important capacities on the hydraulic research and design staffs of the Bureau of Reclamation. To him one of the most satisfying phases of his work has been his part in the foreign exchange program for training engineers from all parts of the world in the hydraulic design practice of the United States. Since January Mr. Bradley has been in the Hydraulic Research Section of the Bureau of Public Roads, in Washington.

Arthur M. Wellington Prize

Six engineers—all of them Californians and all prominently identified with some phase of bridge engineering—are recipients of the Arthur M. Wellington Prize for a paper on "Live Loading for Long-Span Highway Bridges." They are Raymond J. Ivy, A.M. ASCE, supervising bridge engineer for the State Division of Highways at Sacramento, and Stewart Mitchell, M. ASCE, of Sacramento, who retired recently as principal bridge engineer for the

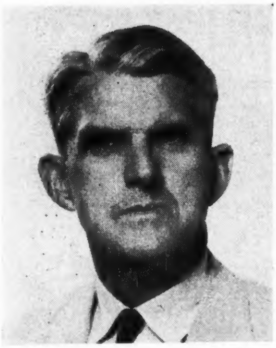


KARL TERZAGHI
Norman Medal



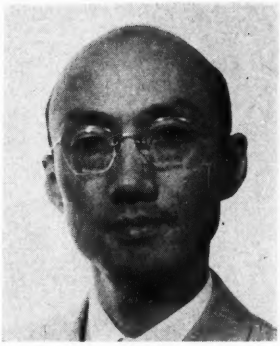
JOHN S. McNOWN
J. James R. Croes Medal

MAURICE N. QUADE
Thomas Fitch Rowland Prize



JOSEPH N. BRADLEY
James Laurie Prize

N. C. RAAB



T. Y. LIN

Two of six winners of Arthur M. Wellington Prize

Division; Prof. T. Y. Lin, M. ASCE, and C. F. Scheffey, J.M. ASCE, of the Engineering Materials Laboratory at the University of California, Berkeley; and N. C. Raab, M. ASCE, chief of the State Division of San Francisco Bay Toll Crossings, in charge of the Richmond-San Rafael Bridge and the southern crossing of San Francisco Bay, and V. J. Richey, A.M. ASCE, senior bridge engineer, San Francisco Bay Toll Crossings.

Collingwood Prize for Juniors

William J. Bauer, J.M. ASCE, who has been awarded the Collingwood Prize for Juniors, has lost no time in living up to the expectations of the Iowa Section, which in 1947 awarded him Junior Membership in ASCE as one of the outstanding civil engineering graduates from the State University of Iowa. Mr. Bauer recently left the Harza Engineering Co., of Chicago, where he was senior designer, to take a similar position with the Chicago consulting firm of John F. Meissner. His prize-winning paper is entitled "Turbulent Boundary Layer on Steep Slopes."

Rudolph Hering Medal

Three authors—two of them brothers—had a hand in the paper on "Flocculation Phenomena in Turbid Water Clarification," which has been awarded the Rudolph Hering Medal. They are Russell G. Ludwig, A.M. ASCE, president of CAL Engineers, of El Monte, Calif., a firm specializing in the design of water-supply and sewerage facilities; Harvey F. Ludwig, M. ASCE, chief of the Office of Engineering Resources of the U. S. Public Health Service, Washington; and W. F. Langelier, professor of sanitary engineering at the University of California, Berkeley, and an authority in the application of chemistry to the solution of water supply and sewerage problems. Mr. Harvey Ludwig and Professor Langelier have cooperated with happy results before, winning the Goodell Prize of the AWWA in 1943 and the Eddy Medal of the Federation of Sewage and Industrial Wastes Associations in 1954.

Leon S. Moisseiff Award

John M. Biggs, A.M. ASCE, winner of the Leon S. Moisseiff Award for his paper on "Wind Loads on Truss Bridges," has been on the engineering faculty at Massachusetts Institute of Technology since 1947 and is now associate professor of

WILLIAM J. BAUER
Collingwood Prize for Juniors

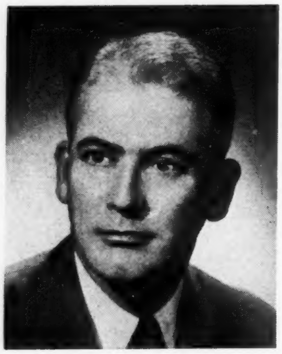
JOHN M. BIGGS
Leon S. Moisseiff Award

RUSSELL G. LUDWIG

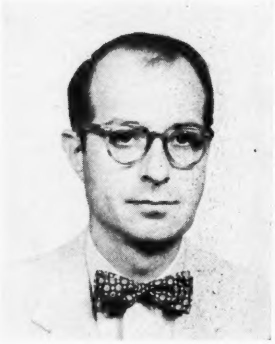
HARVEY F. LUDWIG

W. F. LANGELIER

Co-winners of Rudolph Hering Medal



EDGAR S. HARRISON C. E. KINDSVATER
Co-winners of James W. Rickey Medal



MARION R. CARSTENS
J. C. Stevens Award

structural engineering. Concurrent with his academic duties, Professor Biggs has found time during the past four years to serve as consultant on the design of the Boston Central Artery and conduct research for the Armed Forces on the effect of atomic blast on structures.

James W. Rickey Medal

Edgar S. Harrison, M. ASCE, assistant chief engineer of the Georgia Power Co., and Carl E. Kindsvater, M. ASCE, regents' professor of civil engineering at Georgia Institute of Technology, have collaborated on the paper winning the James W. Rickey Medal. This paper, which is entitled "Dam Modifications Checked by Hydraulic Models," describes one of the numerous sponsored research projects conducted at the Institute under Professor Kindsvater. Professor Kindsvater, winner in his Junior Member days of the Collingwood Prize, recently retired as chairman of the Hydraulics Division's Committee on Research. In his sixteen years with the Georgia Power Co., Mr. Harrison has been responsible for the design of the civil engineering features of a number of large steam-electric stations.

J. C. Stevens Award

Marion R. Carstens, A.M. ASCE, associate professor of civil engineering at Georgia Institute of Technology, will receive the J. C. Stevens Award for his part in the discussion of the prize-winning paper, "Mechanics of Manifold Flow." Professor Carstens has done research on and written about a wide range of fluid mechanics and hydraulic engineering subjects. He is currently the recipient of a National Science Foundation grant for a study of unsteady flow in pipes.

Karl Emil Hilgard Prize

The Karl Emil Hilgard Prize goes to James M. Robertson, M. ASCE, professor of theoretical and applied mechanics at the University of Illinois and Donald Ross, associate professor of engineering research at the Ordnance Research Laboratory, Pennsylvania State University. Their prize-winning paper, entitled "Effect of Entrance Conditions on Diffuser Flow," describes research work on which they were recently engaged at Pennsylvania State University.

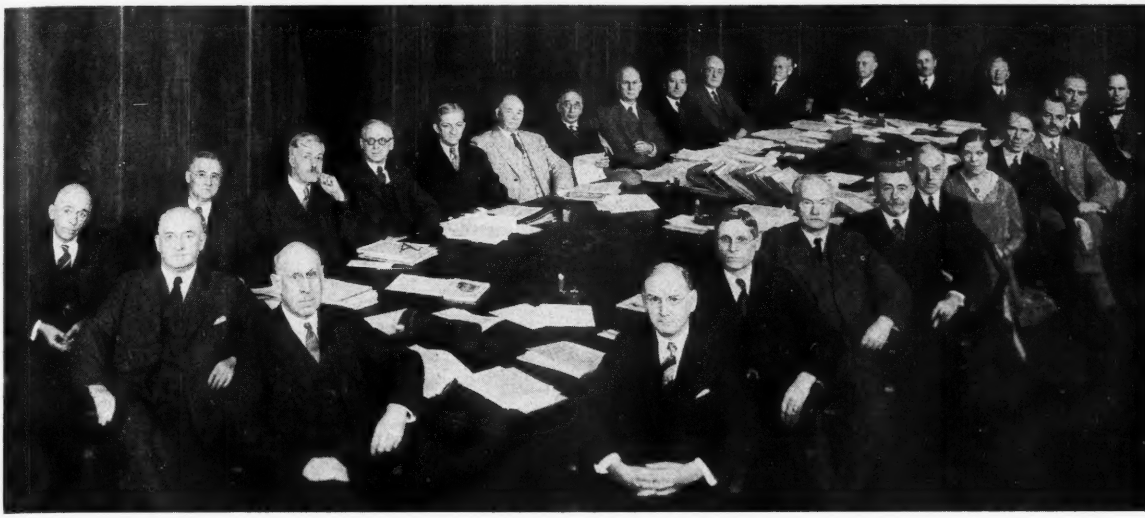
Construction Engineering Prize

John A. Dominy, M. ASCE, Henon Pearce, and Charles C. Zollman, A.M. ASCE, are joint winners of the Construction Engineering Prize for their paper in the August 1954 issue of CIVIL ENGINEERING on "Fast Precasting Schedule for Record-Size Marine Corps Warehouses." Commander Dominy, an officer in the Navy Civil Engineer Corps since 1941, holds many medals for his war service overseas and in the United States. For the past two years he has been deputy district public works officer and district officer in charge of construction at the Fifth Naval Base, Norfolk. Just recently Mr. Pearce became president of his own contracting company, Pearce & Gresham, at Decatur, Ala. For the past nine years he has been field engineer and project manager for the Batson-Cook Contracting Co., at West Point, Ga. Mr. Zollman has been chief engineer of Vacuum Concrete, Inc., since 1951, engaged in all precasting and prestressing phases of concrete construction. He is the author of many technical papers in the field, and is the developer of the precast concrete thin shell roof panels currently in use on several large military warehousing projects.

JAMES M. ROBERTSON
Karl Emil Hilgard Prize

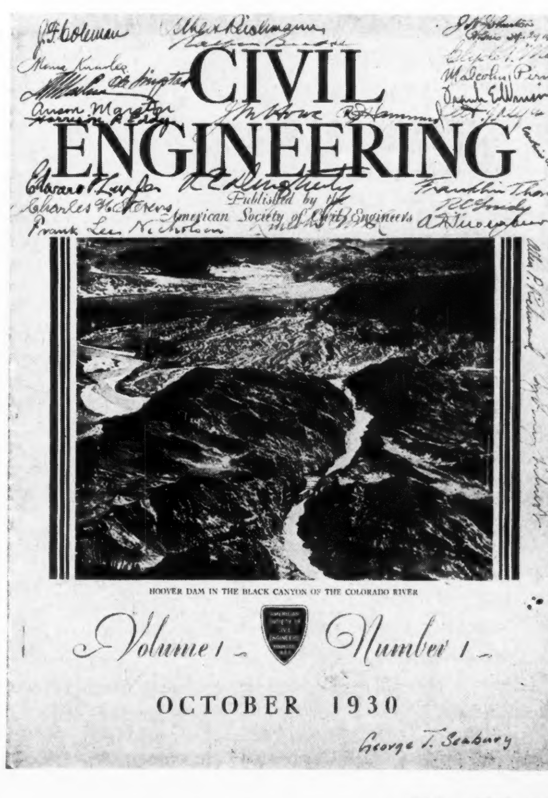
JOHN A. DOMINY HENON PEARCE C. C. ZOLLMAN
Co-winners of Construction Engineeering Prize

Twenty-Five Years Ago



In Board Room at Society Headquarters, the 1930 Board of Direction, which initiated "Civil Engineering," sits in session January 20, 1931. Beginning at left of near corner of table and proceeding clockwise, the members are Harrison P. Eddy, chairman, Committee on Publications, which recommended starting "Civil Engineering"; Edward P. Lupfer; J. Houstoun Johnston; Frank L. Nicholson; A. F. Reichmann; Frank E. Winsor; Charles H. Stevens; Lincoln Bush, Past-President; Joseph Jacobs; A. J. Hammond; Ralph Budd; Roy C. Gowdy; Arthur J. Dyer; Allan T. Dusenbury; Ole Singstad; Morris Knowles; John R. Slattery; R. E. Dougherty; Malcolm Pirnie; J. M. Howe; Carolina Crook; George T. Seabury, Secretary; J. F. Coleman, President; Anson Marston, Past-President; Clyde T. Morris; and Franklin Thomas.

Just off the press in time for the September 29, 1930, meeting of the Board of Direction in St. Louis, Mo., copies of the 68-page first issue of CIVIL ENGINEERING, were passed around the Board table for examination. One of these—on which each member of the Board, the Secretary, and some of his staff placed their signatures—has been preserved, and is reproduced here.



What was the reason for starting this new Society publication? The Publication Committee said, "CIVIL ENGINEERING is needed to amplify the service to members. It is to present some of the Society's technical papers in a form which shall be attractive to a large proportion of the members, thus effecting wider dissemination of knowledge of engineering progress. It is to provide a suitable outlet for material dealing with professional activities, as a means of making the Society a more dynamic force in the nontechnical and professional relations of the engineer. It is to furnish improved facilities for the offices and committees of the Technical Divisions, to inspire and maintain interest in Division work; and for Society committees in the duties and problems assigned to them. It will be the medium through which manufacturers can describe their products to buyers, and thereby keep members informed of progress in engineering materials and equipment . . . A charge will be made for the service commensurate with its value . . . the income . . . will aid in promoting the objects for which the Society has labored for nearly eighty years." Malcolm Pirnie, Morris Knowles, Ole Singstad, Charles H. Stevens, and Harrison P. Eddy, Chairman, made up the committee.

In his message to the then 14,000 members of the Society, President John F. Coleman "hailed CIVIL ENGINEERING as a great progressive step." It took vision and it took courage to embark on a new publication, at a time when our national economy was headed for a depression.

Shown here at ASCE headquarters are nine long-time members of the staff (dates of joining the staff in parentheses). Seated, left to right, are Mary E. Jessup (1930), news editor of "Civil Engineering"; Ruth Campbell, (1930), associate editor of "Civil Engineering"; Eleanora Seifert (1920), administrative assistant; and Ethel Colligan (1923), administrative assistant. Standing, in same order, are Walter E. Jessup (1930), editor of "Civil Engineering"; John Zecca (1930), comptroller; Allen P. Richmond (1929), Assistant to the Secretary; Emil Rothermel (1930), supervisor of mailing department; and Harold Larsen (1927), manager of Technical Publications.

Tellers Canvass Ballot for 1956 Officers

New York, N. Y.
September 15, 1955

To the 1955 Annual Meeting
American Society of Civil Engineers:

The Tellers appointed to count the Election Ballots for Officers of the Society for 1956 report as follows:

For President

(Term October 1955–October 1956)

Enoch Ray Needles	11,350
Scattering	43
Void	5

For Vice-President—Zone I

(Term October 1955–October 1957)

Frank A. Marston	1,673
S. C. Hollister	1,054
Scattering	0
Void	42

For Vice-President—Zone IV

(Term October 1955–October 1957)

Glenn W. Holcomb	3,332
Scattering	7
Void	0

For Director—District 1

(Term October 1955–October 1958)

John P. Riley	1,424
Scattering	11
Void	0

For Director—District 3

(Term October 1955–October 1958)

Carey H. Brown	505
Scattering	1
Void	1

For Director—District 5

(Term October 1955–October 1958)

Mason C. Prichard	239
William H. Richards	145
Scattering	2
Void	7

For Director—District 7

(Term October 1955–October 1958)

Robert H. Sherlock	634
Scattering	3
Void	0

For Director—District 11

(Term October 1955–October 1958)

R. Robinson Rowe	1,872
Scattering	7
Void	0

For Director—District 12

(Term October 1955–October 1958)

Louis E. Rydell	718
Scattering	2
Void	0

For Director—District 16

(Term October 1955–October 1958)

Clarence L. Eckel	621
R. N. Bergendoff	517
Scattering	0
Void	0
Ballots counted	24,215

Ballot envelopes rejected:

Without signature	101
Dues arrears	11

Respectfully submitted,

Albert P. Loriot, *Chairman*
Louis J. Capozzoli, Jr., *Vice-Chairman*

Austin E. Brant, Jr.
Gerard F. Fox
Sigurd Grava
Stanley C. Haug
Herbert Landesman
William D. Patterson
Gordon Wallace
Thomas J. Wickman
Edward R. Wood
Tellers

Disability Plan Benefits For Members over Sixty

The administrators of the Society's Group Disability Plan announce that they have successfully completed negotiations with the Continental Casualty Company for more lenient underwriting practices than were originally announced in Executive Secretary Wisely's letter of August 1, and in the news story that appeared in the August CIVIL ENGINEERING (page 69).

The improvements are as follows:

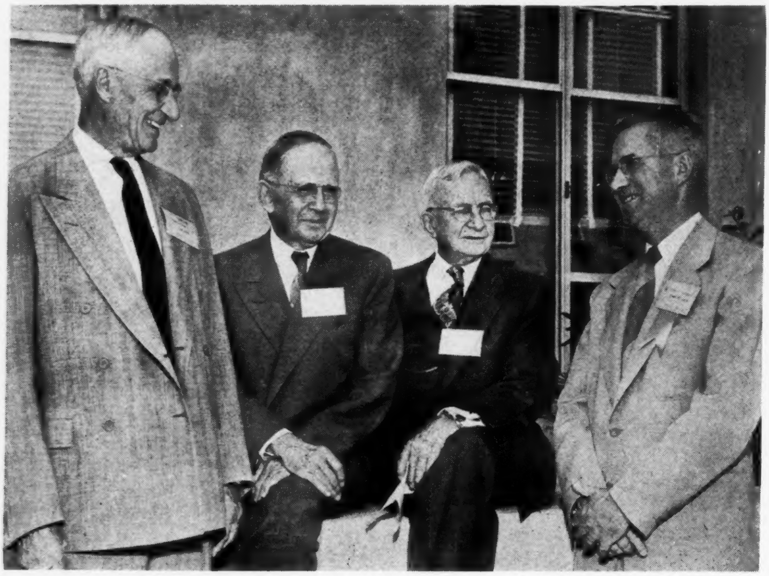
1. Eligibility for the Senior Plan will be predicated only on continuance of membership in the ASCE between the ages of 70 and 80. This eliminates the former requirement that a member be gainfully employed during this period.

2. Entry into the Senior Plan at the age of 70 will be automatic upon application if the member has been enrolled under the Basic Plan for five years or more. Members who attain age 70 and have not been under the Basic Plan for five years, may enroll in the Senior Plan subject to the company's approval.

3. Up to now the optional hospital and surgical coverage under the Basic Plan has been available only to members under age 60. Since the Senior Plan offered this type of protection only to members over age 70, members between ages 60 and 70 have to date been without these benefits. Recognizing this, the administrators have persuaded the Continental Casualty Company to extend hospital and surgical coverage to age 70 under the Basic Plan, without any increase in premium rate.

These improvements liberalize eligibility requirements for members over 60 years of age.

Berkeley Hydraulics Conference Studies Flood Damage



Photographed on the steps of Dwinelle Hall, University of California, where the Hydraulics Division conference was held, are Sidney T. Harding, ASCE Past-President Walter L. Huber, Fred Scobey, and Conference Chairman John K. Vennard.

Nature conspired to provide a giant "laboratory" for flood experience, just preceding the national Hydraulics Conference held in Berkeley, Calif., August 24–26. As might be expected, engineers attending this meeting on the campus of the University of California exchanged a volume of learned comment on the physical aspects of the disastrous August floods, which spread havoc over our New England states, and expressed concern at the suffering and staggering losses involved. As though the sequence of events had been planned, flood forecasting was one of the session that had drawn an advance registration of hundreds.

Cooperating with the Hydraulics Division of ASCE on arrangements for this outstanding event were the San Francisco Section and the University of California, which provided facilities for the sessions.

In addition to the technical sessions the committee on arrangements, headed by Prof. John K. Vennard, of Stanford University, had arranged tours, luncheons, and sightseeing trips in the spectacular San Francisco Bay area. The widely representative attendance was drawn from engineering offices, industries and colleges all over the country. All joined in a luncheon on August 25 to honor Fred C. Scobey, the first chairman of the Hydraulics Division, and one of the few far-sighted engineers who arranged for the organization and authorization of the Division. At this testimonial event, Mr. Scobey was introduced by former Director Sidney T. Harding. There were additional remarks by Past-President Walter C. Huber and Thornton J. Corwin, current chairman of the Hydraulics Division. In his address Mr. Scobey charted the parallel growth of the Division with advances in hydraulic engineering, paying credit particularly to Mrs. Scobey for her encouragement and assistance to his own career in this field.

General conference themes, in addition to the session on floods, were Statistics in Hydrology, Pipeline Flow, and Research in Shoreline Protection. Many of the twenty-odd papers presented will be available later to the membership and profession in the publications of the Society.

Speakers included Walter L. Berry, principal hydraulic engineer for the California Division of Water Resources; Gerald J. Lieberman, assistant professor of statistics at Stanford University; Alfred J. Cooper and Willard M. Snyder, of the Tennessee Valley Authority; David K. Todd, assistant professor of civil engineering at the University of California; Victor A. Koelzer, of the Bureau of Reclamation, Washington, D.C.; Denman K. McNear, assistant engineer, Southern Pacific Railroad Co., Sacramento; Jacob C. Young and R. Robinson Rowe of the State Division of Highways, Sacramento; R. Clifford Youngquist and William H. Kirkgaard, of the Los Angeles Department of Water and Power; Dale M. Lancaster, engineer, Public Works, U.S. Navy; Robert B. Dexter, hydraulics engineer, Bureau of Reclamation; Harrison W. Kramer, consulting engineer, Seattle; Joseph M. Caldwell, chief, Research Division, Beach Erosion Board, Washington; Enos J. Carlson and Carl R. Miller, of the Bureau of Reclamation; John Dunders, of Northwest Technological Institute; and Wallis S. Hamilton, professor of civil engineering at Northwestern University, Evanston, Ill.

For those engaged in the experimental phases of the subject a high spot of the conference was a visit to the host university's hydraulic laboratories, made possible by Morrough P. O'Brien, dean of the College of Engineering, and Harmer Davis, chairman of the Civil Engineering Department. Local arrangements at Berkeley were handled by David K. Todd, assistant professor of civil engineering.

Student Conference to Feature Career Building

Educational, job selection, and licensing phases of career building will be discussed at a Student Conference scheduled for Wednesday afternoon, October 26, during the Society's Annual Convention at the Hotel Statler in New York. Featured speakers on the program, which will be devoted to "Building a Career in Civil Engineering," will be William Allan, dean of the School of Technology, City College of New York; Thomas J. Fratar, associate partner in Tippetts, Abbett, McCarthy & Stratton, New York; and T. Keith Legaré, executive secretary of the National Council of State Boards of Engineering Examiners. Representatives of all the Chapters are urged to make the most of this opportunity to hear top-flight speakers. They may also, of course, attend the many other events of Convention week.

To facilitate housing the visiting students, the Hospitality Committee of the Metropolitan Conference has reserved a

substantial block of double rooms at Sloane House, Y.M.C.A., 256 West 34th St. (two blocks from the Convention Hotel). The rate is $1.50 per person per night. Advance registration is desirable, and requests should be sent to Marshall Jones, Polytechnic Institute of Brooklyn, 85–99 Livingston St., Brooklyn 2, N. Y.

The Organized Conference of Metropolitan Student Chapters will be host to the gathering, under the chairmanship of John C. Totten, Manhattan College.

A Call for Pipeliners

J. B. Spangler, A. M. ASCE

Secretary, Committee on Pipelines

Are you interested in the Committee on Pipelines, which was sponsored by the Construction Division in October 1953? The coupon on page 176 will help you to indicate the extent of your interest. The primary purpose of this Committee as entered in the Society's records is as follows:

"To advance and correlate scientific knowledge and promote and coordinate economic development and construction of engineering projects in connection with the transmission of fluids, gases or solids by means of pipelines and as it pertains, in particular, to the science of civil engineering in the fields of surveying and line location, design, construction and operations, and to promote and further the mutual utilization of the established codes for pressure piping as between pipeline, highway, and railroad groups, and public authorities."

The Committee is primarily interested in the promotion, organization, operation, and management of pipelines whether for liquids, gases, or solids. It has accomplished much since its organization. A Pipeline Conference was part of the spring meeting of the Texas Section at Midland, Tex., in April 1954, and technical sessions were held during ASCE Conventions in New York in October 1954, in San Diego in February 1955, and in St. Louis in June 1955. Many top-flight speakers have appeared on these programs.

The fifteen papers presented at these sessions range from the place of photogrammetry and other methods of pipeline location to details of design and construction of some of the largest and most spectacular pipeline projects—a slight indication of the scope of the field. Authors have included Eldon V. Hunt, chairman of the Pipeline Committee and chief engineer of the Alberta Gas Trunk Line Co., Calgary, Alberta, whose paper was entitled "Scope of Pipeline Transportation in the U.S."; W. H. Davidson, vice-president and general superintendent of Transcontinental Gas Pipe Line Corp., Houston, Tex., on "Revised A.S.A. Code of Pressure Piping"; S. D. Bechtel, Jr., vice-president of the Bechtel Corp., San Francisco, "Construction of Lakehead Pipeline and Mackinac Straits Crossing"; Maj. Gen. S. D. Strugis, Jr., Army Chief of Engineers, Washington, "The Pipelines Carry the Punch"; Rear Admiral John R. Perry, chief of the Navy Bureau of Yards and Docks, Washington, "Defense Pipelines in Spain"; and Prof. Merlin G. Spangler, of Iowa State College, "Stresses in Pressure Pipelines and Protective Casing Pipes."

Some of the papers have appeared either as Proceedings Separates or in Civil Engineering. Most of them have been published in one or another of the many pipeline engineering trade magazines.

The executive committee consists of Eldon V. Hunt (chairman), A. E. Poole, S. D. Bechtel, Jr., W. W. Studdert, S. E. Huey, and J. B. Spangler. In addition, subcommittees are now being established on Programs and Publications (including publicity); Membership; Local Section and Inter-society Cooperation; Pipeline Crossings of Railroads and Highways; Fluid Dynamics; Pipeline Location, Survey, and Mapping; Pipeline Design and Specifications; Pumping and Compression Machinery; and Storage of Pipeline Fluids.

These subcommittees will work jointly, when appropriate, with existing committees under other Divisions to avoid any duplication of effort and to effectively cooperate in gathering and disseminating information to the profession on publications and research in these various fields.

The first step taken by the Committee on Pipelines to fulfill one of its purposes—namely, "to further the mutual utilization of established codes for pressure piping as between pipeline, highway, and railroad groups, and public authorities"—was to schedule at the St. Louis Convention of the Society a fine report by Prof. M. G. Spangler on the safe design for casing pipeline crossings and a proposed code. The American Railway Engineering Association had appointed its member, J. W. Purdy, maintenance engineer of the B. & O. Railroad, Cincinnati, to serve with the Committee on Pipelines as a special representative. Mr. Purdy had a hand in writing the existing AREA Code and is now considering revisions based on Professor Spangler's report.

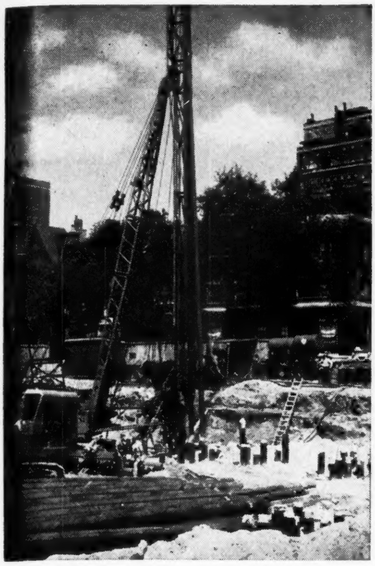
An outstanding two-day conference and a luncheon will be held during the Dallas Convention, February 13–17, 1956. Several interesting papers by experts in the profession have been arranged. Please give the Committee your suggestions for this program and for speakers. If you wish to volunteer as a speaker and to serve on any of the task subcommittees your reply will be most welcome. Use the coupon for this purpose.

Early this year, 189 of the members of the Society scattered around the country signed petitions addressed to the Board of Direction requesting authorization of a new Pipeline Division. Although the Construction Division endorsed this petition, it was not favored by the Committee on Division Activities. The Board of Direction therefore recommended that, until new information indicates the urgency of the need for a new division, our group be encouraged to expand its activities within the framework of the present Pipeline Committee. The Executive Secretary of the Society proposed that we survey the 39,167 members by means of this explanatory item and by having you indicate your interest in our activity by returning the coupon.

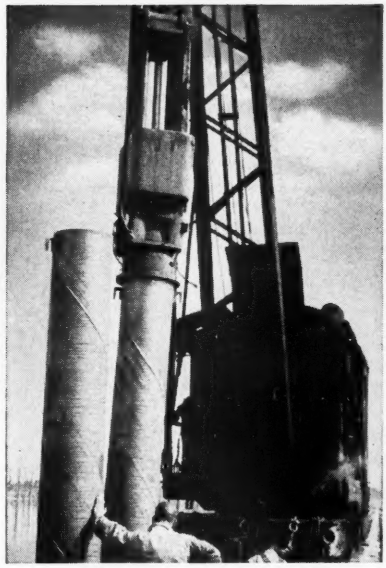
Are you interested in taking part in the work of the Pipeline Committee? Do you believe that we should have a new Pipeline Division? Please indicate in what Division you are now classified and, if you prefer to be affiliated with such a new Division, should it be authorized? If you are interested in pipelining please make the effort to fill out and mail the coupon (page 176).

ASCE MEMBERSHIP AS OF SEPTEMBER 9, 1955

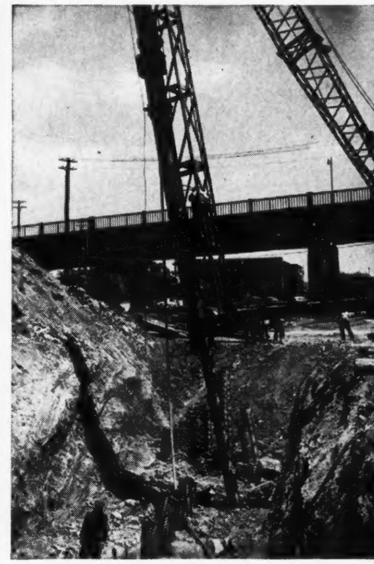
Members	9,052
Associate Members	11,676
Junior Members	18,326
Affiliates	72
Honorary Members	41
Total	39,167
(September 9, 1954	38,085)



Driving Armco Pipe Piles for foundation of Chicago apartment building.



Armco Caissons are being used here in rebuilding old railway bridge.



These Armco HEL-COR Pile Shells will support new superhighway bridge.

Which foundation pipe will handle <u>your</u> job?

Few foundation pipe jobs are alike. But with Armco Pipe Piles, Caissons and Pile Shells to choose from—you'll find it easy to match almost any requirement.

ARMCO PIPE PILES AND CAISSONS are both of welded spiral seam fabrication. They offer high collapse resistance, unusually great beam strength, constant cross-section, and uniform diameter that permits salvaging cutoffs. Pipe piles are supplied with mill-attached plate ends, cone points or cutting shoes. Special cast or fabricated steel shoes can be mill-attached to caissons for open-end driving.

ARMCO HEL-COR PILE SHELLS have helical corrugations and a continuous lock-seam. They are easily handled, light in weight, extremely straight, uniform in diameter and watertight. Cutoffs can be salvaged. Widely used for Cobi mandrel-driven or drop-in shells for the top portion of composite piles.

For specific data on your foundation problems, write us. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 5105 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario. Export: The Armco International Corporation.

ARMCO FOUNDATION PIPE

DESIGN	PRODUCT NAME	DIAMETER O. D.	WALL THICKNESS	LENGTHS
	ARMCO PIPE PILES	8⅝" to 22"	.141" to .500"	Up to 93 feet
	ARMCO CAISSONS	24" to 36"	.375" to .500"	Up to 70 feet
	ARMCO HEL-COR PILE SHELLS	8⅝" to 22⅛"	18 to 14 Gage	Up to 60 feet

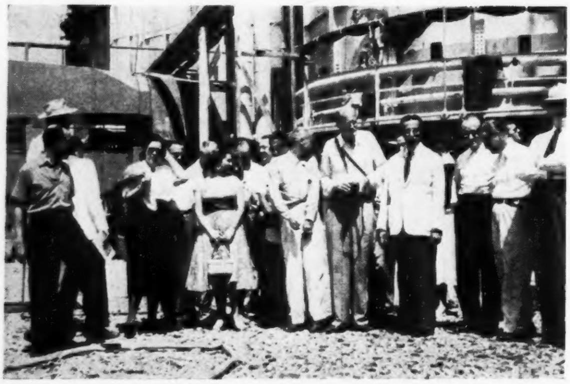
ARMCO FOUNDATION PIPE

NOTES FROM THE LOCAL SECTIONS

(Copy for these columns must be received by the tenth of the month preceding date of publication.)

Attending joint meeting of Texas Section's Austin Branch and the University of Texas Student Chapter are (left to right, in usual order) Earnest F. Gloyna, associate professor of civil engineering, University of Texas; Conrad P. Straub, senior sanitary engineer, Oak Ridge National Laboratory; William F. Guyton, president of the Austin Branch; and Jarvis Michie, president of the Chapter. Dr. Straub was featured speaker with a talk on "Disposal of Liquid Radioactive Waste."

San Francisco Section President Howard Wood (left) and Vice-President Blair Burnson (right) discuss California highway and water problems with Luther Lincoln, leader of the state assembly, at recent Section meeting.



Members of Brazilian Section, accompanied by their wives, visit the Refinaria de Petroleo de Cubatão, a new oil refinery near the port of Santos. Plant has daily output of 45,000 barrels. Group also visited the Cubatão Underground Plant of the Sao Paulo Light and Power Co. under construction by Morrison-Knudsen of Brazil, S.A. Work on this 390,000-kw plant is progressing rapidly, and the first unit will go in service in the first quarter of 1956. W. R. Marinho Lutz, superintendent of the plant and a new member of ASCE, accompanied the group.

Scheduled ASCE Conventions

NEW YORK CONVENTION
New York, N. Y.
Hotel Statler
October 24–28, 1955

DALLAS CONVENTION
Dallas, Tex.
Hotel Baker
February 13–17, 1956

KNOXVILLE CONVENTION
Knoxville, Tenn.
University of Tennessee
June 4–8, 1956

Coming Events

Kansas City—Hydraulics Conference at Continental Hotel, Kansas City, November 21 and 22.

Mid-South—Annual fall meeting at the Claridge Hotel, Memphis, Tenn., October 20–22.

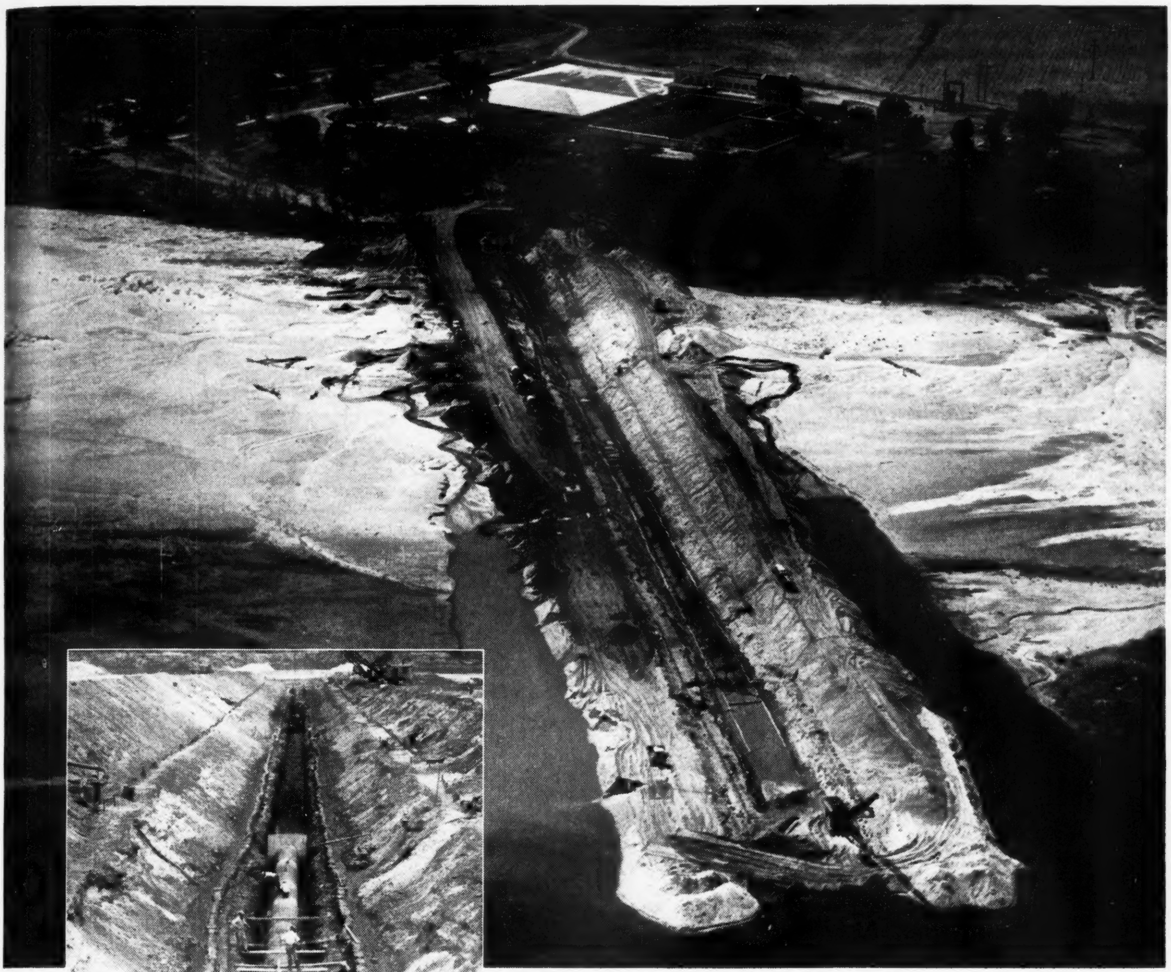
Northeastern—Joint dinner meeting with the Boston Society of Civil Engineers at M.I.T., Cambridge, October 19. Student Chapter members in the area will be guests of the Section.

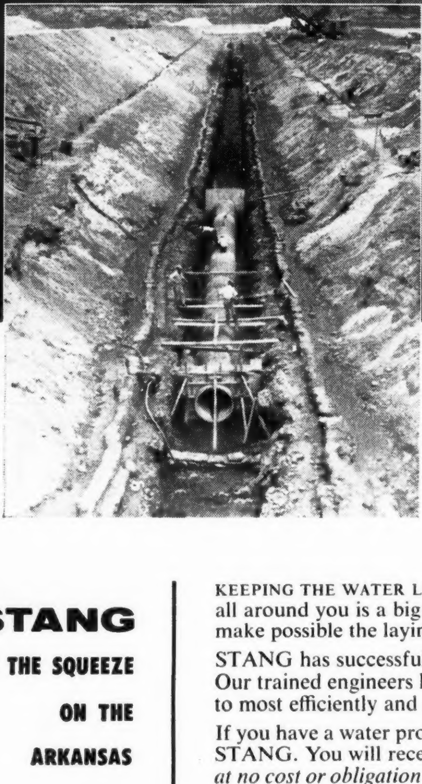
Oklahoma—Annual meeting at Norman, Okla., on the morning of November 26.

Seattle—Annual joint dinner meeting with the Tacoma Section at the Boeing Cafeteria, October 12. Program and inspection trip will be sponsored by Boeing.

Tennessee Valley—Fall meeting at Oak Ridge, Tenn., November 4 and 5, with the Oak Ridge Subsection as host.

Texas—Fall meeting at the Texas Hotel, Fort Worth, Tex., October 13–15.





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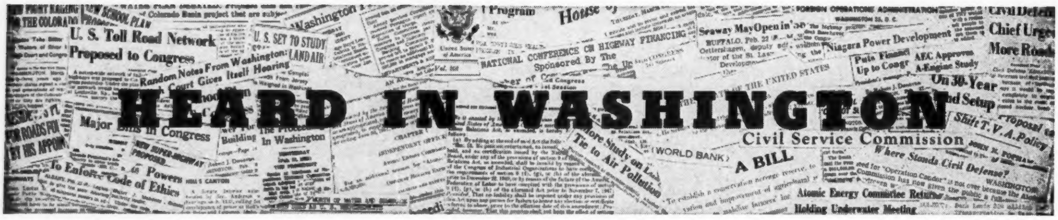


JOSEPH H. EHLERS, M. ASCE **Field Representative ASCE**

Legislative accomplishments of the 84th Congress—First Session

The first session of the 84th Congress is charged with leaving many things undone, but the list of public laws already passed which are of interest to engineers is impressive. It includes the following, in addition to numerous appropriation measures:

P.L. 31—Authorizes new headquarters building for Atomic Energy Commission.

P.L. 94—Increases salaries of federal employees about 8 percent.

P.L. 106—Authorizes construction of a $36,000,000 Museum of History and Technology for the Smithsonian Institution, to house important engineering exhibits.

P.L. 111—Expands the program for research in conversion of saline waters, including grants-in-aid.

P.L. 129—Authorization for $57,000,000 to complete the Inter-American Highway was voted.

P.L. 138—Mutual Security Act—overhauls the foreign-aid programs.

P.L. 141—Authorizes expansion of the atomic energy program.

P.L. 159—Provides for research and technical assistance in air-pollution control—research and grants-in-aid to public bodies (August issue, page 74).

P.L. 161—Authorizes military construction for Army, Navy and Air Force and new headquarters for Central Intelligence Agency.

P.L. 211—Federal Airport Act—program of 50-50 matching grants-in-aid to local public bodies: $47,000,000 new funds this year and $63,000,000 for each of the next three years. First long-range aid program for airports.

P.L. 216—Two-year extension of the Contract Renegotiation Act; most construction contracts awarded through competitive bidding exempted.

P.L. 305—Reserve Forces Act of 1955—provides for a military reserve of 2,900,000 men by 1959. Makes it possible to enlist for 6 months active and $7^1/_2$ years reserve training.

P.L. 345—Expansion of slum clearance, community facilities, college housing, and advance planning programs of the Housing and Home Finance Agency.

P.L. 369—Increases annuities for retired Civil Service workers.

P.L. 381—Increases federal minimum wage to $1 an hour.

P.L. 386—Authorizes a $225,000,000 Trinity River Project, an extension of California's Central Valley development.

Numerous important bills still remain for further consideration in the second session, commencing January 3, 1956.

S. 890, a bill to increase **stream-pollution control** activities was passed by the Senate. It provides for broadened research and for financial grants to support state programs. It also provides a revised procedure for solution of interstate pollution problems. With a few amendments, passage seems likely.

Schools—House committee approved a bill for a four-year program of federal **grants-in-aid to states for school construction,** totalling $1.6 billion. Some controversial questions, such as segregation, may become involved in this.

The Senate approved S. 500—the controversial **Upper Colorado River Project.** This involves fundamental questions of federal water policy. Bills for federal development of **Hell's Canyon** and for New York state development of power at **Niagara** are held in committee in both Houses. The House passed a $110,000,000 authorization for deepening channels connecting the **Great Lakes.**

Highways—The rejection of **highway legislation** in the first session will spur lively debate. If the proposed 90 percent or greater federal contribution on the Interstate System is to be retained in the bills, it would seem that some equalizing funds would have to be given to states not materially benefiting from it, in order to get the necessary votes. Many problems remain before developing a limited access Interstate System—some scheme to provide competitive commercial establishments on the highway is needed; vehicle limits and highway standards that will be sound for the future must be based on sound findings of transportation economics. It seems likely that some compromise measure will finally emerge.

Contracts—The proposed **Federal Construction Contract Act** to require advance naming of mechanical specialty contractors on federal jobs was passed by the Senate and is under consideration in the House Judiciary Committee.

The Individual Retirement Act (H.R. 9), strongly supported by the engineering societies was approved by the House Ways and Means Committee and will be considered in a package tax-reduction program. Treasury objects but may accept some compromise proposal costing government less.

Social Security—Extension liberalizing benefits was passed by the House (August issue, page 74).

Registration for Canal Zone—In the closing hours of the session a bill was introduced to establish registration for engineers in the Canal Zone. It will be considered by the House Merchant Marine Committee.

Washington, D.C.
September 16, 1955

NEWS BRIEFS . . .

Construction Activity Maintains Record Level in August

Outlays for new construction continued at peak levels in August, approximating \$4 billion and bringing the total for the first eight months of the year to an all-time high of \$27.1 billion, according to preliminary estimates of the Departments of Labor and Commerce. After adjustment for seasonal factors new construction activity in August was at an annual rate of \$41.5 billion. This compares with the record annual rate of \$42.4 billion achieved in May 1955, an average rate of \$41.7 billion for the first eight months of 1955, and actual outlays of \$37.6 billion during 1954.

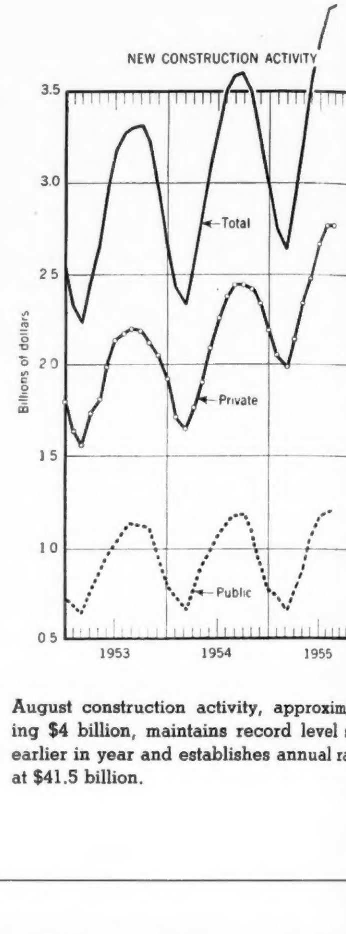
The total value of new work put in place last month was 8 percent above the previous August high in 1954. Private expenditures for new construction this August (\$2.8 billion) were 12 percent above last year's figure, while total public outlays (\$1.2 billion) were off slightly.

Most major types of construction showed normal seasonal movement between July and August this year. However, activity on stores and similar establishments showed an unseasonally sharp increase, reaching a new monthly peak. On the other hand, private residential construction (which usually remains steady) edged off, reflecting a downtrend in housing starts during the preceding two months. Highway construction rose less than seasonally, largely because of the heavy rains and flood damage in the Northeastern states due to recent hurricanes. Conservation and development work and construction of military facilities failed to advance the usual amounts.

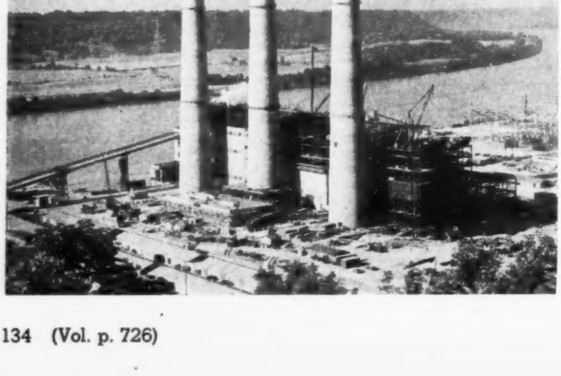
Dollar volume thus far in 1955 was at record levels for private residential building, commercial buildings (including offices as well as stores), public schools, churches, sewer and water facilities, public utilities, and highways. Schools, churches, and utilities, in addition to commercial buildings, also set a new monthly record in August.

Private activity accounted for almost the entire increase over 1954, when the first eight months of each year are compared, with private residential building alone accounting for over 70 percent of the total dollar gain. The only private categories that did not show an over-the-year increase were farm, railroad, and school construction. New private construction as a whole totaled \$19.3 billion during the January-August 1955 period—about one-fifth more than in the corresponding months of 1954.

On the other hand, public expenditures, at \$7.8 billion, were about the same this year as last for the first eight months. Declines in public industrial building (mainly installations for the Atomic Energy Commission), conservation and development work (virtually all on reclamation and TVA projects), public housing, and hospital construction nearly offset gains in public educational buildings, military installations, sewer and water facilities, and highways.



August construction activity, approximating \$4 billion, maintains record level set earlier in year and establishes annual rate at \$41.5 billion.



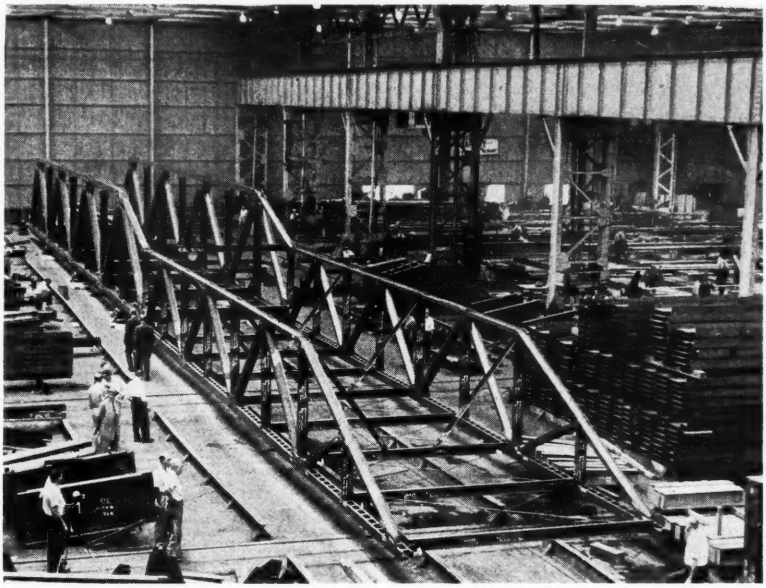
More Kyger Creek Power Goes on the Line

Sixth of eleven giant steam-electric generating units—being built by the Ohio Valley Electric Corp. to supply full electric power for the AEC's Portsmouth (Ohio) Project—went into operation early in September. This 215,000-kw installation, which brings OVEC generating capacity up to 1,290,000 kw, is the third unit at the Kyger Creek Plant on the Ohio River near Gallipolis, Ohio. Its sister unit was placed in operation in July at the Clifty Creek Plant on the Ohio River at Madison, Ind. When completed early in 1956, the two stations will be the largest power plants ever built by private enterprise. Clifty Creek will have six units with total generating capacity of 1,290,000, and Kyger Creek five units with total capacity of 1,075,000 kw. Ground was broken at both plant sites in December 1952, marking the start of a schedule that called for simultaneous construction of the two power plants, 180 miles apart, and the completion of their eleventh and final unit in slightly less than three and a half years.

A-E Firm Engaged for New AEC Headquarters

Selection of the New York City firm of Voorhees, Walker, Smith and Smith to perform the architect-engineer services for the construction of an AEC headquarters building is announced by Kenneth E. Fields, general manager of the Atomic Energy Commission. Congress has authorized the Commission to construct a permanent headquarters building costing up to $10,000,000 in or near the District of Columbia.

Launching Nose Expedites Bridge Building



Removable nose cantilevers bridge across an imaginary chasm in balancing test at the Elmira, N.Y., plant of the American Bridge Division of U.S. Steel. This launching method for rolling a bridge across a stream or gorge is used on a new type of adaptable span highway bridge. The demonstration was carried out with the first of three 120-ft spans sold to the Republic of Colombia by the U.S. Steel Export Co. In the launching process the nose, which is 80 ft long and weighs 14 tons, is assembled on a river bank. After the first bridge section has been assembled, the nose is attached at the end toward the stream. As the bridge sections are completed, the launching nose and the attached structure are rolled out over the stream. The nose is detached after each launching and can be used over and over again.

Washed-out Railroad Span Replaced in Record Time

Eight days after fabrication began, a job that would normally take months was completed by U.S. Steel's American Bridge Division, when two 109-ft girders were shipped from the Ambridge plant to replace a washed-out span on the mainline of the Erie Railroad. In the Delaware River floods late in August the 100-year-old stone arch over Panther Creek at Shohola, Pa., disappeared along with hundreds of other structures. The Delaware Valley lay buried in the wreckage, and restoration seemed months away.

Engineers who were helping to direct the clearing of the wreckage made a thorough inspection of the bridge foundations. They decided that the old footings would serve to support a modern steel bridge and drew up replacement plans. Verbal orders and specifications outlining the steel requirements were received at Ambridge on August 31. The fabricating shops were ready to go to work on the project when the blueprints arrived two days later, although some of the steel needed to fabricate the 50-ton girders was yet to emerge from the open hearths and rolling mills of U.S. Steel's Homestead District Works.

The two girders were shipped in a record eight days, and the job was completed at the bridge site by September 11, enabling the Erie to resume traffic over its mainline.

Stalactites in Carlsbad Caverns Survive Blasting

Modern explosives and controlled blasting techniques made it possible for engineers to blast for the excavations required in the construction of a new elevator shaft and parking lot at the Carlsbad Caverns National Park in New Mexico without damage to the existing shaft or to the delicate rock formations within the caverns. Both standard and short-period delay caps were employed to minimize rock vibration.

Most of the 754-ft deep, 9 × 16-ft shaft was sunk from above, only the bottom 60 ft being cut with raise rounds. The shooting was a particularly delicate operation, since it was performed less than 25 ft from the existing elevators, which operated on normal schedule during the work, and directly above the fragile rock formations that give the caverns their unique beauty. Careful attention to the size and effect of each blast permitted the job to be completed with no damage to either the existing elevators or the rock formations.

Line drilling on 3-in. centers was employed on the side next to the existing elevators to give an opening to shoot to, and to reduce the transmission of vibrations through the wall of rock. Atlas Gelodyn and Giant Gelatin dynamites and standard delay electric blasting caps were used exclusively to break the 3,500 cu yd of rock removed. Cutting of the new elevator shaft was done by the Boyles Brothers Drilling Co., of Salt Lake City, Utah.

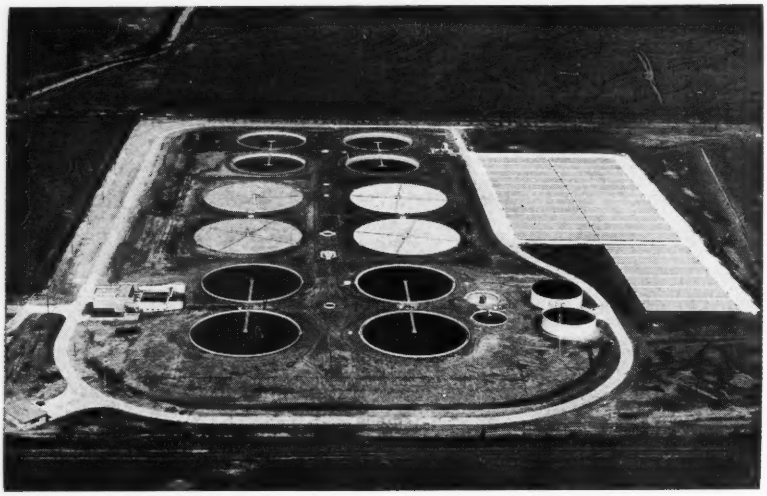
Council for Improved Neighborhoods Formed

Formation of ACTION, a non-profit organization which has for its aim improving housing conditions, should be of interest to civil engineers. Its plan calls for eliminating at the source the factors that cause dwellings, neighborhoods, and communities to decline in livability and value, by conserving our good houses, rehabilitating those that have felt the touch of blight, and eliminating the slums which have deteriorated beyond hope of reclamation.

ACTION will accomplish these objectives by: (1) Gathering and providing facts upon which constructive action can be based; (2) generating citizen awareness and motivating individuals to take action; and (3) providing, on request, specific assistance to communities that wish to take action.

The organization may be addressed in care of Box 462, Radio City Station, New York 20, N.Y.

Southwest's Biggest Biofiltration Plant Begins Operation



Careful planning of the recently opened $2,387,000 sewage-treatment plant at Beaumont, Tex., and utilization of the most up-to-date treatment methods result in remarkably low operating cost for the 30-mgd unit—largest biofiltration plant in the Southwest. Part of a $6,500,000 program for improving the city's sewerage system, the plant has two 50-ft-dia Densludge Thickeners that enable a single Dorr Multdigestion System with 80-ft primary and secondary digesters to handle a designed population load in excess of 200,000. The two-stage biofiltration flowsheet is of the series-parallel type, in which a portion of settled raw sewage is constantly passed to the second stage filter, insuring even distribution of initial food supply between first and second stage filtration. Each of the four Dorrco distributors serving the primary and secondary filters is 195 ft in dia—among the biggest ever built. Design of the project was handled jointly by engineering consultants George J. Schaumburg, of Beaumont, Tex., and Forrest & Cotton, of Dallas. The Tellepsen Construction Co., of Houston, was the builder.

Generator Contract For Chief Joseph Dam

The Westinghouse Electric Corp. has received a Department of the Army contract for six generators for Chief Joseph Dam, which is being constructed as a part of the Army's multiple-purpose plan for the development of the Columbia River Basin. Westinghouse was the low United States bidder for the generators, with a total bid of $6,338,491.

Water Producing as Industry Studied at A.C.S. Meeting

More than 1,000 towns and cities suffered from water shortages last year, members of the American Chemical Society were told at their recent annual meeting in Minneapolis. It was suggested that present shortages and increasing use may make it necessary to process water from saline or brackish supplies on a commercial scale. This solution was presented in a report, based on a recent survey of water usage.

Commenting on the report, E. R. Gilliland, professor of chemical engineering at the Massachusetts Institute of Technology, noted that the supply problem is actually a problem of cost. In some agricultural and industrial areas, he said, the cost is only one cent per thousand gallons, while in other places it is $10 for the same quantity. The average charge is around 30 cents a thousand gallons.

With modern methods of refinement, Dr. Gilliland said, "good water can be obtained by distillation in quantities of 5,000,000 gpd or more at prices ranging from 75 cents to $2 a thousand gallons. In smaller quantities the price could be $3." Freezing was suggested as potentially one of the best methods of obtaining fresh water, with costs on a large scale as low as 25 cents a gallon. However, major technological problems must still be solved. Ion-exchange columns have been used with good results on a small scale, Dr. Gilliland said, but costs run very high. He also mentioned recently developed electrical membrane systems, which can treat sea water for about 60 cents a gallon on a large scale.

Belgian Engineers in North America Establish Society

Recent organization of the Belgian Engineers in North America, which includes all graduates of Belgian engineering schools living in the United States, Canada, etc., is announced by Leon G. Rucquoi, M. ASCE, president. Mr. Rucquoi is technical and economic consultant in New York for the Steelmakers and Metalworking Industries of Belgium and Luxembourg. Leon A. Fraikin, president of the Franki Foundation Co. in New York, is vice-president of the new organization, and Max Lorié, general director of the American International Trade and Service Co. in New York, is secretary. Any inquiries should be sent to Mr. Lorié at Suite 1700, 50 Broadway, New York 4, N.Y.

The group has slightly over 100 members.

New York Has New West Side Airlines Terminal

A $5,000,000 airlines terminal building has just been opened at Tenth Avenue and 42nd Street in New York to serve airline passengers bound for Newark Airport. Traveling time to Newark Airport for buses departing from this new facility and using the Lincoln Tunnel will be only 20 minutes—shortest trip to a major airport from Manhattan. Airline passengers for New York International and La Guardia Airports will continue to use the East Side Airlines Terminal, opened in late 1953.

The new four-story terminal building provides parking space for 200 cars at the basement level.

Merritt-Chapman & Scott Forms Roadbuilding Unit

To round out the operational scope of its Construction Division the Merritt-Chapman & Scott Corp. has acquired two New England-based construction companies active in roadbuilding and a wide range of other heavy construction—the Savin Construction Corp., of East Hartford, Conn., and its subsidiary, the Whaling City Dredge & Dock Corp., of Groton, Conn.

Merritt-Chapman & Scott's Construction Division and the Savin Construction Corp. have been closely associated since 1950 as joint-venture contractors on several major projects. Currently they are building Folsom Dam in California for the Corps of Engineers.

Shot-crete Walls for Low-Cost Homes

Reinforced concrete homes with attractive simulated stone facing are being built to sell substantially under the Washington area market as a result of special techniques and tools developed by Virginia builder, Merle H. Gillespie.

The most important of the time-and money-saving techniques developed consists of erecting exterior concrete walls without forms. Essentially, the process involves shot-creting concrete over a course of steel welded wire fabric backed up by insulation board. The insulation board, with a minimum thickness of $^3/_4$ in., is notched into a 2 × 7$^1/_4$-in. wooden top plate and recessed 12 in. into the foundation. The fabric is held in position 1$^1/_2$ in. in front of the insulation. The assembly of insulation, fabric, and top plate is temporarily positioned by a series of wooden triangular jigs and walers which back up the insulation board. The jigs remain steady on the ground slab through gravity and friction, resisting the thrust of the concrete as it is applied by nozzle to the exterior of the insulation.

After concrete has been "shot" against the exterior, around and over the welded wire fabric to a thickness of 4 in., the triangular jigs are removed. Sheet aluminum foil is then applied with mastic over all the interior area of the insulation board, the reinforcing fabric positioned, and shot-crete subsequently applied to a depth of 2$^1/_2$ in.

Patent application has been made for the entire process involving the construction of the exterior walls without forms. The resultant 4-in. wall qualifies under the ACI code as a bearing wall and, in combination with the insulation and the interior wall, offers superior insulation qualities as well as startling economies in construction. (The wall has a computed *u* factor of 0.27.)

In the metropolitan Washington area, conventional wall construction costs range from $12 to $16 per sq per sq ft, whereas the Gillespie method comes to about $10 per sq. ft. An obvious saving of time results from the fact that the basic walls for a three-bedroom home can be "shot" in a day and a half.

The second important factor in the Virginia builder's system is a machine he designed and had made for applying colored concrete for simulated stone or brick. His machine can be built and sold at a cost of about $1,000, compared with $7,000 for the conventional shot-crete machine. Despite its deceptive simplicity of design, the machine (using a 1-hp electric motor and 105-cu ft air compressor) will deliver 2 cu yd of mix an hour at continuous feed.

The machine is used to apply one-course "plastering" or colored concrete finished off as Roman brick for interior walls, and colored concrete for exterior walls, finished off as coursed ashler, Tennessee crab orchard stone, cut limestone, or random field stone. The machine is being patented, but Gillespie's method of mixing his color pigments to produce a varied and highlighted natural stone finish is his secret.

The next component in the system is the cut-off or strike-off screed for interior walls. This is a giant-size tool resembling an immense cheese slicer. Tension, applied to one side of the 8-ft tubular steel frame, tautens a piano wire which acts as a cutting edge and slices back to a level surface the rapidly setting concrete.

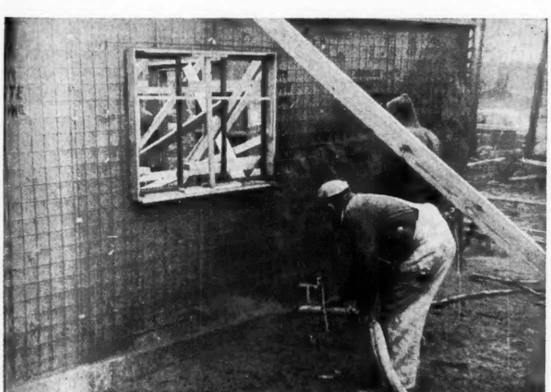
Finally, to complete his wall construction system, the enterprising designer and builder has developed various templates, 7- by 3-ft sheets of galvanized steel which are slotted into patterns resembling the spacing of different stone facings. The exterior of the building is marked according to the templates. Then, using a tubular thin steel cutting tool of his own

Gillespie-designed tubular tool, used to cut back through inch or inch and a half of colored shot-crete and, by exposing darker colored natural concrete, form deep-raked "mortar" joints between "courses."

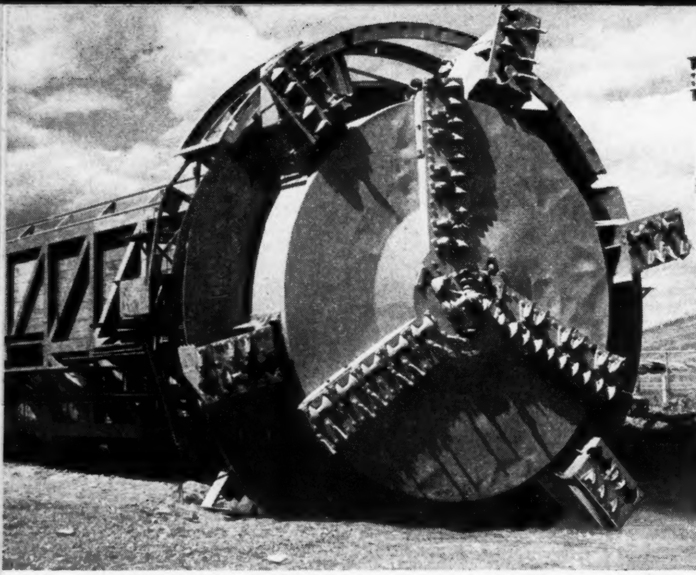
design, Gillespie cuts back through the 1 to 1$^1/_2$ in. of colored concrete to the darker colored natural concrete and thus forms deep, raked "mortar" joints with attractive shadow lines between the "courses" of stone.

Shot-creting of the basic home is done with a CMC jetcrete mixer and gun, which has a dry-material capacity of 5 cu yd per hr. In-place capacity of this machine is 3$^1/_2$ to 4 cu yd per hr. Both the CMC and Gillespie's machine are continuous-process, and are loaded with the dry mix by a screw-type wheat loader. Gillespie's mix ratio is one bag of cement to 4 cu ft of sand, with water added at the nozzle in the ratio of 2$^1/_2$ to 3 gal to a bag of cement, depending on the sand-moisture content.

The interior walls of the home (other than outside walls) are shot 2$^1/_2$ in. thick over 6 × 6-$^6/_6$ welded wire fabric against reusable plywood forms. The floor is finished either with asphalt tile, parquet, or wall-to-wall carpeting.

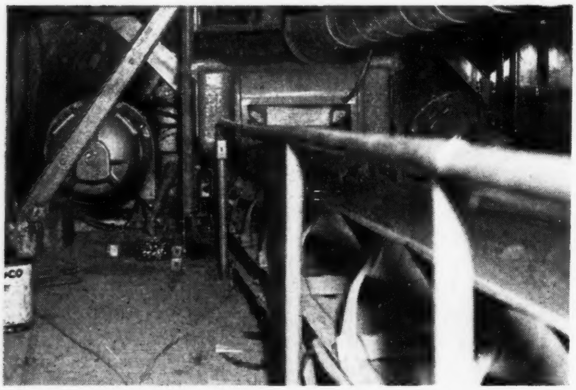


Workmen "shoot" exterior of Gillespie home, building the sand and cement plastic mix up to 4 in. over the 4 × 4-6/6 welded wire fabric (left-band photo). Basic walls for this home may be "shot" in a day and a half with the Gillespie system. Insulation board serves as form, but remains in completed wall, between exterior and interior shot-crete. In view at right workmen complete cutting back of welded wire fabric reinforced shot-crete walls to resemble Tennessee crab orchard stone. Right-hand upper portion of front wall is cut like V-joint siding. Wire Reinforcement Institute photo.



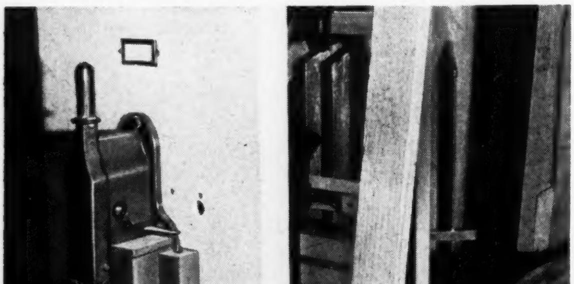
MECHANICAL MARVEL shows its mighty teeth. The 26-foot cutting face can be raised, lowered, and swung from side to side to alter direction of cut. Note concentric cutter heads and shale scoops.

IMMENSITY OF JOB is suggested by view of six tunnel entrances bored in record time by new mole (above). Reinforced concrete tunnels average 1830 feet long.

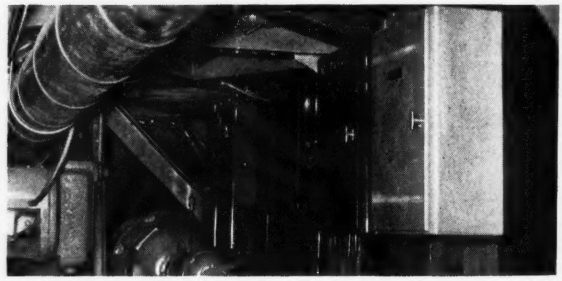


DIGGER'S RELIABILITY depends largely on performance of two 200-hp G-E wound-rotor motors driving cutters through gear mechanisms. Conveyor carries rubble to cars at rear of mole.

THREE COMPACT 167-kva G-E transformers in digger step down power supplied by cable from diesel-generator outside.



PROTECTION of electrical system is provided by dead-front panel with circuit breaker and ground relay. Compact General Electric equipment had to fit into tight space available.



G-E MOTOR CONTROLLERS provide short circuit protection and permit centralized push-button control at operator's station.

EXACT FORWARD MOVEMENT into rock face is accomplished with highly dependable G-E 25-hp motor furnishing power for hydraulically operated "feet" which propel mole on tracks.

GENERAL ELECTRIC

Electrically powered by General Electric . . .

New giant "mole" chews tunnels 26′ wide over 4 times faster than previous methods

Mittry Constructors' tunnel digger illustrates high productivity possible with electrified tools

At the Oahe Dam of the Missouri River development near Pierre, S. D., an electrified tunnel digger 90 feet long has slashed tunneling time, costs and dangers. This imaginative use of electricity is even more successful than anticipated by its pioneering designers. James S. Robbins and Associates, Chicago, designed and built the "mole" for Mittry Constructors of Los Angeles under license from Goodman Mfg. Co., Chicago. According to Robbins, help from J. R. Porter, G-E engineer, greatly contributed to completing the digger two months ahead of schedule.

Problem was extremely difficult: How to dig six tunnels each over one-third mile long without exposing shale more than 30 days? Longer exposure would dry and dangerously weaken shale.

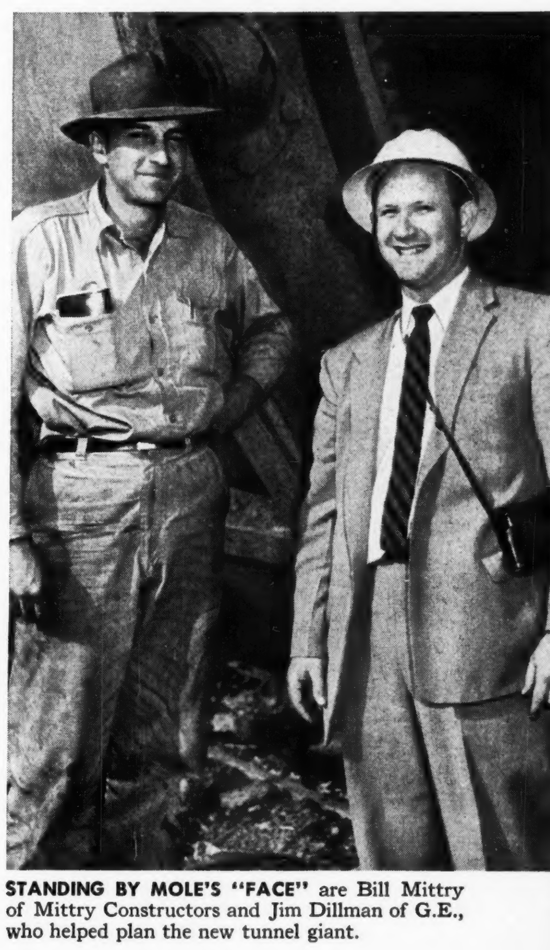
Solution was new electrified tool, which dramatically cut tunneling time to less than one fourth that needed by other methods. Digger was designed with two motor-driven concentric revolving cutter heads with large shale scoops on outside ring. Sections revolve in opposite directions to equalize cutting torque. Scoops dump shale through hopper to conveyor belt. Every four feet, a large I-beam is rammed into shale walls for support. Concrete is then pumped into forms to finish walls.

Down time has been practically zero. Despite conditions such as a constant humidity of 95% in the tunnels, G-E equipment has reliably powered this giant mole continuously and efficiently.

Electrified construction tools can pay off the same way for you too. Let your G-E Apparatus Sales representative show you how G-E equipment, backed by G-E engineering service, can raise tool productivity. Contact your nearest G-E Apparatus Sales office, or write General Electric, Sect. 664-37, Schenectady 5, N.Y.

Engineered Electrical Systems for Heavy Construction Tools

GENERAL ELECTRIC



STANDING BY MOLE'S "FACE" are Bill Mittry of Mittry Constructors and Jim Dillman of G.E., who helped plan the new tunnel giant.

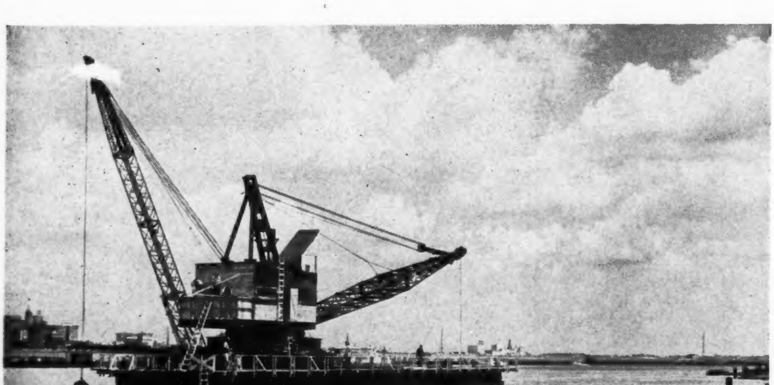
Artist's rendering of $65,000,000 Mississippi River cantilever bridge, which will connect New Orleans and Algiers, La., shows the 1,575-ft center span, longest in the United States and third longest in the world. Rendering was prepared by Julian Michele.

Work Under Way on New Mississippi Highway Bridge

Construction of the huge new highway bridge over the Mississippi River at New Orleans is proceeding on a schedule that calls for opening the structure to traffic in 1958. The bridge is being built for the Mississippi River Bridge Authority—an agency of the State of Louisiana, the Parishes of Jefferson and Orleans, and the City of New Orleans. When completed it will be part of an overall plan of the Louisiana Highway Department and the U. S. Bureau of Public Roads for improvement of the Interstate Highway System in the New Orleans area. Financing is provided by a $65,000,000 issue of revenue bonds.

The first construction contract was awarded on February 1 to the Dravo Corp. on a low bid of $6,691,590. Ground was broken by Dravo on March 25, and sinking of caissons for the four main bridge piers is in progress.

The main river crossing will be a three-span cantilever structure, with a 1,575-ft center span and side spans of 591 and 853 ft, respectively. It will require four main piers. One of the piers is located on the New Orleans bank, the second will be in the river 555 ft out from the wharf line, the third on the batture of the west bank, on the river side of the levee, and the fourth 450 ft landward from the levee in Algiers. The first three will be founded on open dredged caissons, and the Algiers anchor-arm will be founded on piles. The river pier will be of unusual size, the caisson (shown in one of the photos) being 88 by 151 ft. It will be sunk about 180 ft below low-water level. The pier on the batture will be founded on a caisson $61\frac{1}{2} \times 135\frac{1}{2}$ ft in plan at a depth approximating El. -165.



Huge reinforcing concrete caisson for one of four piers for new Mississippi River bridge has ten dredging wells each $14\frac{1}{2}$ ft square. Caisson will be sunk 83 ft to become the base of Pier No. 1. Dravo Corp., Pittsburgh, is building the piers for the Mississippi River Bridge Authority.

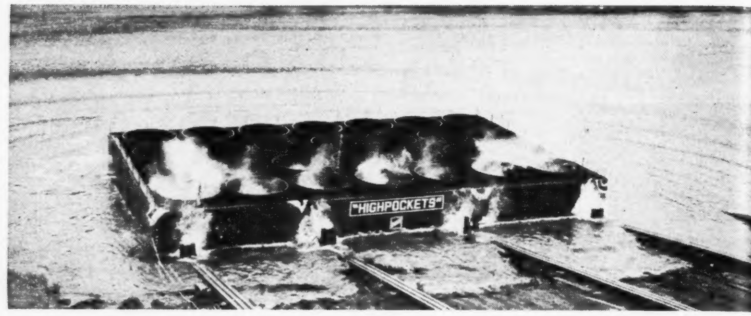
The main cantilever superstructure will provide 150 ft of vertical clearance for navigation, measured above high water, over a 750-ft width of the main channel of the river. Shipping activities in the New Orleans area are relatively heavy along the wharves extending upstream and downsteam from the bridge site. A new wharf has been constructed across the bridge site at the waterfront by the New Orleans Dock Board, and the new bridge must be erected over it in such a way as to avoid damage to the wharf. A vertical clearance of 133 ft over high water will be provided at the face of the wharf, and with more than 500 ft of horizontal clearance to the river pier, there will be ample space for the handling of vessels along the wharf front.

With the height of the bridge greater than that of other structures in the New Orleans area, it will become the dominating feature of the city's skyline. The main span will be exceeded in length only by the 1,800-ft span of the Quebec Bridge over the St. Lawrence and the notable Firth of Forth Bridge in Scotland. It should be noted that the maximum navigation opening was much narrower in

(*Continued on page 142*)

these two longer spans, and it was consequently possible to design their trusses with sloping lower cords. The older structures also have the advantage of firm foundations of rock or other hard materials. In the New Orleans area, it is necessary to found the piers in yielding sand and clay strata, expecting and providing in the design, for some settlement due to consolidation of the underlying soils.

The new Mississippi Bridge will have a 52-ft-wide roadway, providing four 13-ft lanes, two for traffic in each direction. If and when traffic volume requires, it will be possible to divide the roadway for five lanes of traffic—three in one direction and two in the other at times of peak movement. Under this arrangement the center lane will be reversible, for use in either direction, as traffic may require.



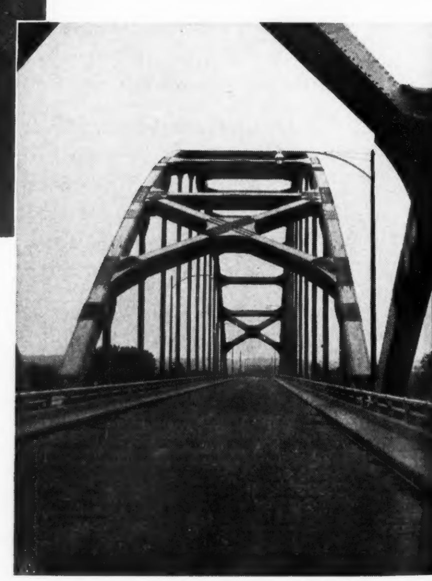
Here 500-ton floating steel caisson slides into the Ohio River from launching ways at Dravo's Neville Island (Pittsburgh) shipyard to begin first leg of 1,850-mile journey to New Orleans. The 151-ft-long caisson, resembling a giant honeycomb, will be sunk 180 ft in the Mississippi River at New Orleans to become the bottom of the foundation for Pier No. 2.

Through the main span, the roadway profile will consist of a vertical curve 1,800 ft long, connecting with grades of 1.45 percent in the anchor arms and with 3.5 percent grades on the approach structures. The main bridge section—from the New Orleans anchor pier to the Algiers anchor pier—will be 3,019 ft in length. The entire project under jurisdiction of the Authority is 2.3 miles long. It includes the main bridge, its viaduct approaches, and a toll plaza with administration buildings at ground level at the end of the Algiers approach. The New Orleans approach terminates at Camp Street in an elevated connection with the Pontchartrain Expressway which is being built concurrently by the Louisiana Department of Highways. The Authority will build street connection ramps at Camp Street, and the Highway Department will construct a number of ramps along the expressway in the city for access and exit of bridge traffic. The Highway Department is also constructing a new express highway facility, which will serve the west bank communities and connect directly with the bridge toll plaza.

Modjeski & Masters are consultants to the Mississippi River Bridge Authority on the design and supervision of construction of the new bridge, its approaches and the plaza. George S. Covert is director of the Louisiana State Department of Highways. The Authority consists of Neville Levy, chairman; W. O. Turner, vice-chairman; Senator Alvin T. Stumpf, secretary; Richard W. Freeman, treasurer and Robert L. Simpson, John W. Stone, and W. Richard White. Frank X. Armiger is administrator, and Charles E. Cassagne, Jr., chief engineer.

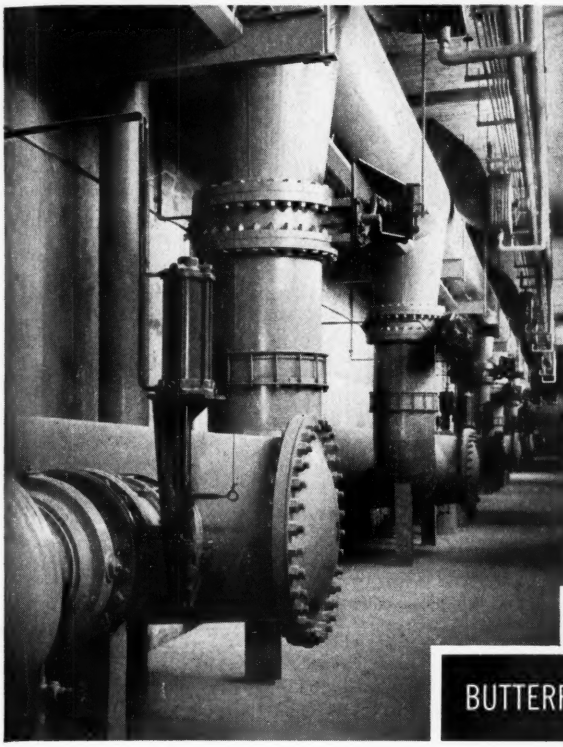
Information for this article was supplied by C. W. Hanson, M. ASCE, partner in the Modjeski & Masters firm.

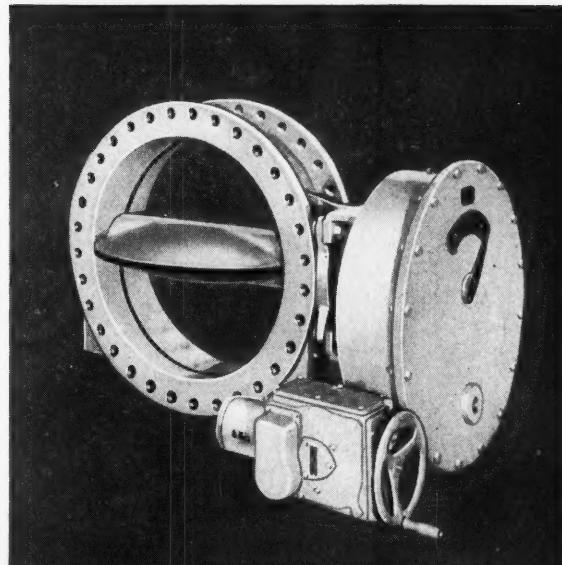
New Leavenworth Bridge Constructed in Record Time



Recently opened Leavenworth (Kans.) Centennial Bridge across the Missouri River between Missouri and Kansas was completed in a record eighteen months. It is a two-span continuous, tied-arch structure supported on three piers. The east approach viaduct has seven deck-girder spans, and the west approach viaduct nine. Total length of the project, including the approaches, is about 6.5 miles, with the distance between abutments 2,436 ft. The 26-ft-wide roadway has $2^1/_2$-ft walks on each side. Thirty octagon-shaped, continuous tapered Kerrigan Weld-forged steel lighting standards with 370-w G.E. lamps provide effective modern lighting. Part of the construction cost of $3,500,000 (originally estimated at $4,000,000) was shared by the Missouri and Kansas State Highway Commissions, and the remainder financed by bond sale. Howard Needles, Tammen & Bergendoff were the consulting engineers and designers, and the Kansas City Bridge Co. was the principal contractor.

DROP-TIGHT SHUTOFF R-S Rubber-Seated Butterfly Valves give drop-tight closure to 125 psig through wedge-type action of the disc within a one-piece rubber seat. 65 of these valves, installed as shown for service in the San Jacinto River project near Houston, gave a substantial space reduction and direct, in-place cash savings of $124,000.





FOR HIGH-PRESSURE SERVICE SMS Babbit-Seated Butterfly Valves are built to give tight shutoff and meet the rugged demands of high-pressure service. They are available for shutoff pressures up to 200 psig, and for a wide range of velocities, including open-end free discharge.

BUTTERFLY VALVES

GET POSITIVE SHUTOFF, CUT CONSTRUCTION COSTS

For high or low-pressure water service, SMS has the Butterfly Valve to give you tight shutoff and help reduce construction costs. Using SMS or R-S Butterfly Valves in place of conventional gate valves permits a much more compact piping layout, means substantial savings in the initial building costs. For full information on the complete SMS valve line – Butterfly Valves, Ball Valves and Rotovalves – see our local representative or write S. Morgan Smith Co., York, Pa.

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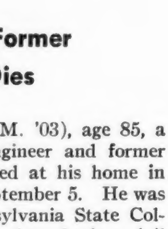
DECEASED

Edward Robert Armstrong (M. '21), age 78, retired consulting engineer of Monroeville, N.J., died in a Philadelphia hospital on July 6. For many years Mr. Armstrong was research engineer in the Mechanical Experimental Division of the E. I. du Pont de Nemours Co. in Wilmington, Del., which he joined in 1914. While there he conceived the idea of "Seadromes," floating landing fields for trans-Atlantic flights, which attracted wide attention and discussion. In his later years he was with the Sun Shipbuilding & Dry Dock Company, Chester, Pa., retiring in 1952.

George Harmon Bayles (M. '13), age 77, consulting engineer of Morgantown, W. Va., died on July 16. A graduate of West Virginia University, Mr. Bayles was employed for many years in South America and Mexico. His positions included office engineer on industrial plant, sewerage, and housing construction projects in Chile; construction engineer on an oil refinery at Minatitlan, Mexico; construction superintendent for Ulen & Co. on municipal works construction at Bogota, Colombia; and assistant superintendent for D. P. Robinson & Co. on dam construction in eastern Brazil. Mr. Bayles worked for various railroads here, and was city manager of Morgantown, W. Va., from 1923 to 1925.

George Clarke, Former ASCE Director, Dies

George C. Clarke (M. '03), age 85, a noted construction engineer and former Director of ASCE, died at his home in New York City on September 5. He was graduated from Pennsylvania State College in 1891 and returned to obtain a civil engineering degree in 1902. With the Engineering Department of the Pennsylvania Railroad from 1891 to 1911, Mr. Clarke rose to the position of engineer in charge of construction of the Pennsylvania terminals in New York City and Pittsburgh. In 1911 he became a partner in the firm of Fraser, Brace & Co., remaining in that association until his retirement in 1945. During his long connection with the firm he was engaged in the construction of many hydroelectric and industrial projects in Canada, including metallurgical plants and smelters for the International Nickel Company of Canada. He was also actively engaged on outstanding projects in the United States, such as the Federal Shipyards at Kearny, N.J., in World War I and a number of large government ordnance works during World War II.



George C. Clarke

When Mr. Clarke became a Director in 1911 he was one of the youngest at the time to have held high Society office.

Charles Alvin Emerson (M. '15), age 73, since 1940 a member of the New York City consulting firm, Havens & Emerson, died in Orange, N.J., on August 24. Mr. Havens graduated from Beloit College in 1903, and two years later received a sanitary engineering degree from Massachusetts Institute of Technology. His early experience was with the Baltimore Sewerage Commission and the Pennsylvania State Department of Health—for nine years as chief engineer. Since 1923 he had been in private consulting practice in New York—from 1923 to 1936 with Fuller & McClintock, and from 1936 to 1940 with Gascoigne & Associates. Active in organizing the Federation of Sewage and Industrial Wastes Associations, Mr. Emerson served as its president for eleven years.

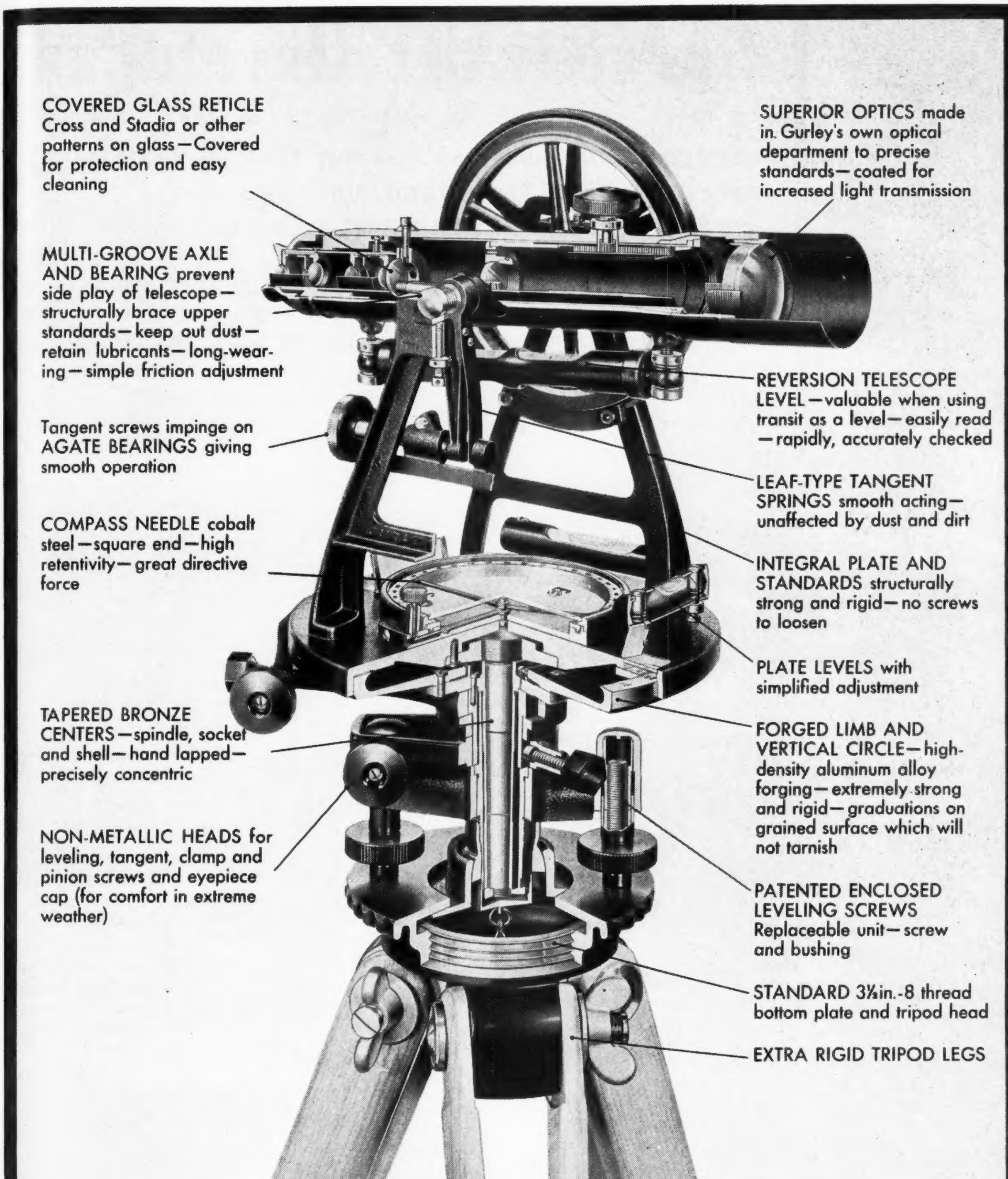
George Edwin Howe (M. '30), age 70, engineer of Denville, N.J., died on May 17. Mr. Howe had been with the engineering department of the American Bridge Company, a division of U.S. Steel Corp., in New York City, since 1900, and was assistant engineer from 1919 until his death. He received a civil engineering degree from the Polytechnic Institute of Brooklyn in 1925.

Andrew P. Hustad (M. '27), age 74, since 1919 a member of the Hustad Company, Minneapolis, Minn., consulting firm, died on June 9. Following graduation from the University of Minnesota in 1908, Mr. Hustad worked for the C.A.P. Turner Co., in Minneapolis—from 1910 to 1919 as principal assistant engineer and manager.

Thomas Henry Irving (M. '23), age 71 New York City architect and engineer, died recently. A graduate of Cooper Union Institute, class of 1905, Mr. Irving was a designer for the Concrete Steel Engineering Co. from 1906 to 1917. From the latter year to 1919 he was with the U.S. Navy Public Works Department in Philadelphia, and from 1919 to 1925 with Ballinger & Perrot Architects, New York City. He then formed a partnership, McKenna & Irving (later Thomas H. Irving) in New York City. Mr. Irving specialized in adjoining church and school buildings.

Earl Joseph Lynde (M. '47), age 64, chief sanitary engineer for the Pasadena (Calif.) Water Department, died on July

(Continued on page 148)



The Gurley Precise Transit

W. & L. E. Gurley, Troy, N. Y.

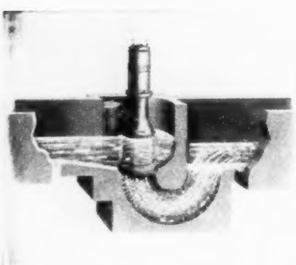
GURLEY

Specifically Developed

25 YEARS OF PROGRESS

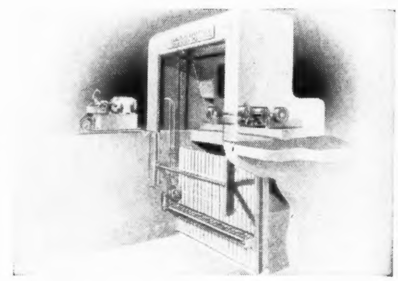
EXCLUSIVE CONTRIBUTIONS FOR THE SEWAGE & WASTE TREATMENT FIELD BY CHICAGO PUMP COMPANY, *WITH OVER 18,000 INSTALLATIONS TO DATE!*

Displayed on these pages are some of the better known processes and equipment for sewage and industrial waste treatment developed and introduced by Chicago Pump Company since 1930. Engineered to meet specific problems of sewage treatment, they represent the widest line of treatment equipment available—for comminution, grit removal, aeration, digestion and pumping.



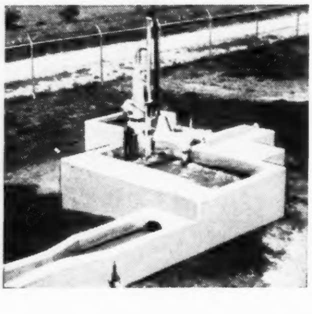
COMMINUTOR—BARMINUTOR

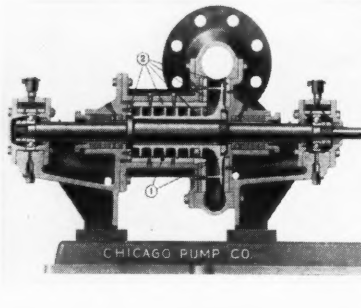
Chicago Pump comminution equipment for sewage flows from .005 to 250 MGD per minute, installed in a 6″ pipe, and basin or a rectangular channel section.



AER-DEGRITTER

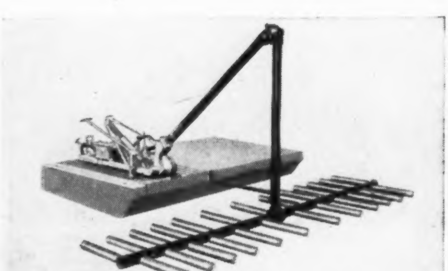
. . . provides air controlled settling velocities independent of flow, removing grit and sand from sewage, with no need for separate washing tanks.

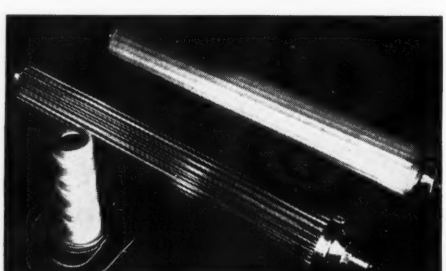




SCRU-PELLER PUMP

. . . provides continuous multiple shearing action through cutting edges of the screw and cutting bars in the pump housing, which permits truly clog-proof operation.





SWING DIFFUSERS and PRECISION DIFFUSER TUBES

Developed to provide Chicago Pump Company's Wide-Band Aeration System, the Swing Diffuser has been used in 95% of all new plants since 1940—over 300 treatment installations—permitting service of the diffuser tubes without de-watering from the tank. This equipment also allows for the use of Chicago Pump Company tapered aeration process, which assures that sewage receives oxygen in amounts equivalent to demand. With Swing Diffusers, Precision Tubes provide more effective aeration and simplified cleaning.

Deceased

(*Continued from page 144*)

14. Mr. Lynde had been with the Water Department since 1932, and was in charge of the Sanitation and Purification Division from 1941 on. Earlier he was city engineer and water superintendent of Sierra Madre, Calif., and general manager of the Western Tile & Marble Co., Pasadena. He attended the University of Nebraska, and was a veteran of World War I.

George Allen Noyes (A.M. '46), age 44, of Montrose, Calif., died suddenly on June 27. Following his graduation from the University of California in 1938, Mr. Noyes entered the U.S. Engineer Office in Sacramento, Calif. He served, successively, as junior engineer, principal engineering aide, assistant engineer and, after 1943, associate engineer in charge of airport construction.

John Freeman Rand (M. '50), age 56, Lieutenant Colonel, U.S. Air Force, and commanding officer of the 4050th Air Refueling Wing, Eighth Air Force, Westover Air Force Base, Mass., died there on May 6. For many years a resident of Melrose, Mass., he had been city engineer in the Public Works Department and for sixteen years had a private practice there. In 1942 he was commissioned a major in the Air Force and served in the Pacific Theater. Since 1945 he had been staff engineer, post engineer, and air installations officer at Orlando, Fla., Mitchell Base, N.Y., and in Okinawa. Colonel Rand was educated at Northeastern University and M.I.T.

Nicholas Anthony Rose (M. '50), age 46, since 1948 consulting ground-water geologist of Houston, Tex., died on July 16. A graduate of Vanderbilt University, class of 1933, Mr. Rose started his career as geologist with the T.V.A. In 1939 he joined the U.S. Geological Survey as ground-water geologist. From 1946 to 1948 he worked for the Houston firm, Lockwood and Andrews.

Robert Smith (A.M. '43), age 50, for the past twenty years chief architect of the Austin Co., Cleveland, Ohio, died July 31 at his home in Kirtland, Ohio. With the company since 1936, Mr. Smith was primarily responsible for the architectural design of such outstanding structures as N.B.C.'s Radio City in Hollywood; the American Rolling Mill Company's research laboratories in Middletown, Ohio; the Bell Aircraft Company's Niagara Frontier plant; and the W.A. Sheaffer Pen Company's plant, Fort Madison, Iowa. Mr. Smith was educated at the John Huntington Polytechnic Institute.

Edward Charles Stocker (M. '22), age 73, of McAllen, Tex., died on May 23. A graduate of the University of Wisconsin, class of 1909, Mr. Stocker worked for many years in Shanghai, China. He started with the Shanghai Municipal Council in 1911, later becoming assistant engineer with the Whangpoo Conservancy Board, and finally chief engineer with the Texas Co. Ltd.

Engel Bert Van de Greyn (M. '51), age 73, who had been bridge engineer with the New Mexico State Highway Department from 1925 until his retirement in 1951, died in Santa Fe on July 23. A graduate of the University of Illinois, class of 1911, Mr. Van de Greyn had a private practice in Houston, from 1915 to 1917 and then joined Beaumont Ship Building and Dry Dock Co., at Beaumont, Tex., where he was chief engineer and later manager.

Walter Augustus Vaught (M. '29), age 71, since 1940 civil engineer with the U.S. Corps of Engineers at Nashville, Tenn., died on July 15. For twenty years Mr. Vaught was principal assistant to J. R. Rhyne, consultant of Corning, Ark. He became resident engineer for the Arkansas State Highway Commission in 1933, and later was associate engineer in the U.S. Department of Agriculture on Mississippi Valley projects. Mr. Vaught received a B.S. degree in 1909 and a C.E. degree in 1911 from Virginia Polytechnic Institute.

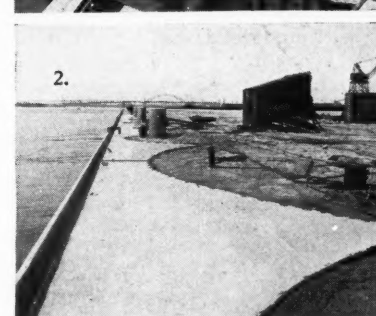
Sheet-piling cells are 60 ft in diameter and contain 150 separate piles. Connecting arcs contain 22 piles. Total tonnage of sheet piles was over 6200.

When completed, pier will be surfaced and equipped with latest-type cargo-handling equipment. Piles were driven by Northern Metal Co., of Philadelphia, Max Rose, president.

1. Fender system consists of H-piles and structural shapes welded to steel cells.

2. Steel plate cut to fit curves of cells and connecting arcs, completes fender system.

3. Pier has almost perfect alignment. 1000 tons of H-piles were used in fender system.



SHEET-PILING CELLS FOR 120-ACRE PIER DRIVEN IN 40 FT OF WATER

Thirty-five permanent sheet-piling cells and connecting arcs were driven in 40 ft of water in the construction of this huge new pier for Northern Metal Company, of Philadelphia. Over 1,500,000 cu yd of fill were used behind the cells to form a pier with 120 acres of storage space, and with 2400 ft of water-front berthing space.

Each cell has a diameter of 60 ft and is made up of 150 Bethlehem Steel Sheet Piles. The connecting arcs contain 22 piles. In all, more than 7200 tons of Bethlehem Piling were used in constructing the pier, including 1000 tons of H-piles used to build the fender system with which the pier is fronted.

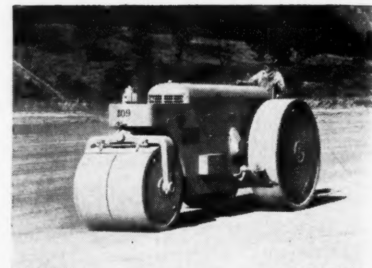
The piling was so carefully placed that when the fender system is completed and the steel plates are in place, it is expected that alignment will be almost perfect along the waterfront.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corp. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

THE BUFFALO-SPRINGFIELD K-45 KOMPACTOR



3-WHEEL ROLLERS

How to select compaction equipment

The logical question to ask yourself when you are ready to buy new compaction equipment is: "Exactly what do I need the equipment for and how will I use it?"

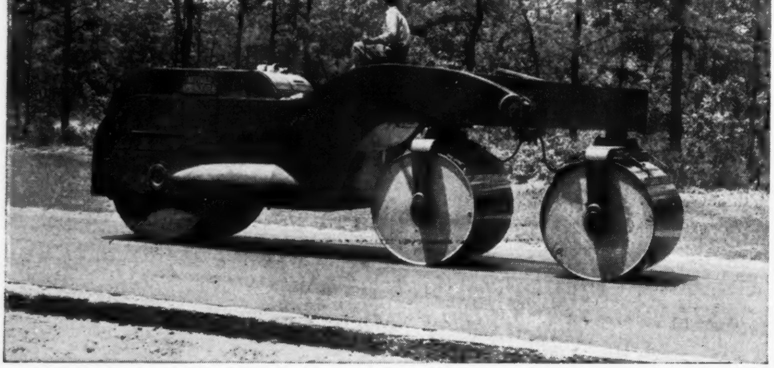
BASE FILL COMPACTION—This type of compaction demands equipment that will handle a wide variety of materials, give you the highest degree of compaction with the fewest passes. Buffalo-Springfield's revolutionary K-45 Kompactor is proving a real money-making answer for this type of work. It is self-propelled, relies on the "Interrupted Pressure Principle." All compaction effort is directed downward. Contractors testify they are meeting density requirements in one-fourth the time normally required with other compaction equipment.

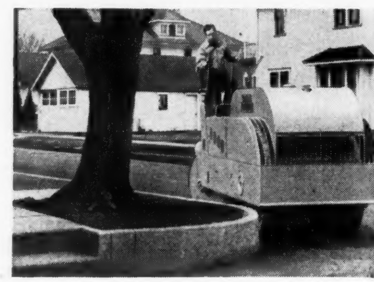
FINE GRADE FINISHING—Buffalo-Springfield offers six 3-wheel rollers, ranging in capacity from 5 to 15 tons, to handle the large variety of materials found in fills, subgrades and unfinished bituminous pavements. The variable-weight 3-wheel roller is ruggedly built for years and years of hard, maintenance-free work.

Buffalo-Springfield's thoroughly-proved 3-axle tandem "walking beam" roller provides up to 60% greater tonnage compacted per day in superhighway construction, airport and military establishment jobs where specifications are extra strict.

ASPHALT FINISHING—Two-axle Tandem Rollers are designed especially for all surface finishing jobs. Ranging from 5 to 16 tons, Buffalo-Springfield Tandems are used for heavy-duty highway and public works projects, and all types of finishing, maintenance and repair work. A wide selection of models for the biggest to the smallest jobs are designed for long-life and profitable operation.

THE BUFFALO-SPRINGFIELD KX-3 AXLE TANDEM





TWO AXLE TANDEMS

SHORT ROLLING JOBS—Buffalo-Springfield's 3-5 ton portable roller is widely used for rolling driveways, sidewalks, parking and playground areas, and for patching and light finishing jobs. It is highly maneuverable and portable from job-to-job. Write today for full information on the type of equipment you need—or see your nearest distributor for an on-the-job demonstration.

3-5 TON PORTABLE TANDEM

The Standard of Comparison

BUFFALO SPRINGFIELD

SPRINGFIELD, OHIO

On schedule . . . through the winter . . .

Christopher Columbus Houses, Newark, N. J., as of March, 1955.

Owner: HOUSING AUTHORITY, City of Newark, N.J.
Architect: WM. E. LEHMAN, Newark, N. J.
Contractor: TERMINAL CONSTRUCTION CORP., Wood Ridge, N. J.
Ready Mix Concrete: J. P. CALLAGHAN CO. Harrison, N. J.

. . . WITH LEHIGH EARLY STRENGTH CEMENT

Careful planning, good management and Lehigh Early Strength Cement kept construction on Newark's First Ward Housing Project moving at a steady pace through the winter of 1954-1955.

The quick curing concrete, made with Lehigh Early Strength Cement, enabled Terminal Construction Corporation to strip column forms in 24 hours, beam and arch forms in 48 hours. Curing time was cut by two-thirds. *And within 2½ working days after a pour, all forms were in place on the floor above, ready for the mechanical trades.*

Each day's pour—approximately 200 cubic yards—was completed before noon. With less bleeding and earlier hardening of the Early Strength concrete, finishers were off the job by 3:30 P.M. Overtime costs and unproductive overhead were cut to a minimum.

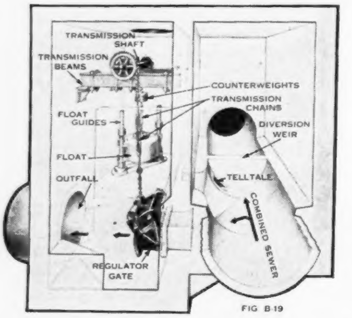
Remember Lehigh Early Strength Cement when planning winter concrete work. It will help you speed construction, cut costs.

LEHIGH EARLY STRENGTH CEMENT
LEHIGH PORTLAND CEMENT
LEHIGH AIR-ENTRAINING CEMENTS
LEHIGH MORTAR CEMENT

LEHIGH

PORTLAND CEMENT CO. *Allentown, Pa.*

AUTOMATIC SEWAGE REGULATORS



The regulating equipment shown above comprises (1) a gate unit with a belled inlet wall casting leading from the combined sewer, (2) a float unit including a float, float guides with collars for limiting the float travel and (3) a transmission unit including shaft with wheels and universal roller bearing pillow blocks, supporting beams with wall brackets, transmission chains with adjusting means and counterweights so positioned that the float itself over balances the gate shutter by an amount equal to approximately two inches of float submergence. The float unit is positioned in a separate compartment connected to the combined sewer with a telltale pipe.

REGULATOR GATE SIZES

GATE NO.	TUBE SIZE VERT. HOR.	AREA SQ. FT.	GATE NO.	TUBE SIZE VERT. HOR.	AREA SQ. FT.
7-0	5" × 6"	.21	7-A	16" × 38 5/16"	4.28
6-0	5" × 7 1/2"	.26	8	21" × 32 5/8"	4.76
5-0	5" × 9 1/4"	.32	8-A	21" × 35 3/8"	5.16
4-0	7 1/2" × 7 3/4"	.40	8-B	21" × 38 1/8"	5.56
000	7 1/2" × 9 3/4"	.51	9	21" × 40 3/4"	5.94
00	7 1/2" × 12 3/8"	.64	9-A	21" × 44 1/8"	6.45
0	7 1/2" × 15 3/8"	.80	9-B	21" × 47 5/8"	6.95
1	12" × 12"	1.00	10	28" × 38 1/4"	7.44
2	12" × 15"	1.25	10-A	28" × 40 1/2"	7.91
3	12" × 18 3/4"	1.56	10-B	28" × 42 7/8"	8.37
3-A	12" × 21"	1.75	10-C	28" × 45 3/8"	8.84
4	12" × 23 3/8"	1.95	11	28" × 47 7/8"	9.31
4-A	12" × 26 5/16"	2.19	11-A	28" × 50 1/8"	9.78
5	16" × 21 3/8"	2.40	11-B	28" × 52 9/16"	10.25
5-A	16" × 24 3/8"	2.74	11-C	28" × 55"	10.72
6	16" × 27 1/2"	3.05	11-D	28" × 57 3/8"	11.18
6-A	16" × 30 7/8"	3.43	12	28" × 59 3/4"	11.62
7	16" × 34 1/4"	3.81			

Fig. DS-267. Digit numbers indicate 19 "stock" sizes of Regulators; numbers with letter suffix indicate 16 "split" sizes which are readily available. All sizes are regularly made in several types to accomplish their several purposes as follows:

TYPE A CONTROL: If it is desired to shut off all flow to the interceptor when such flow has reached a predetermined state of dilution due to storm the regulator is arranged as shown by Figure B-19. In this arrangement the float compartment is fed by a tell-tale pipe leading from the combined sewer.

While this type is primarily designed to shut off all flow to the interceptor during storm periods it may be readily adjusted so that the regulator gate will not shut off completely and some flow will pass to interceptor at all times.

TYPE B CONTROL. If it is desired that interceptor become charged to predetermined point before reducing the diverted flow the regulator arrangement differs from Figure B-19 in that the tell-tale pipe to float compartments leads from the interceptor. Sixty-nine of this type of regulator are in use in the City of Detroit and vicinity.

TYPE C CONTROL. Sometimes it is desired to pass a predetermined quantity through the regulator gate regardless of conditions in either the combined sewer or the interceptor. In this case the regulator acts as a governor and the float is actuated by the flow after it has passed through the regulator gate and before it is discharged from the regulator chamber.

This type of control can generally be designed so that the desired Q may be governed within the limits of plus or minus 7 percent. The flow is diverted from the combined sewer in the usual manner. An orifice plate is inserted between the regulator gate and

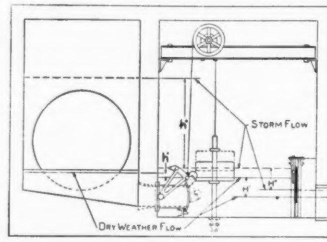


Fig. DS-239. Type C Control

the outfall pipe. The size of the orifice is determined for full open regulator gate and for Q minus 7 percent. Under dry weather conditions this splits the total available head loss into h' which causes flow through the gate and H' which causes flow through the orifice. Next, using Q plus 7 percent, the maximum head loss under storm conditions is split into h" and H". The difference in flow lines between regulator gate and orifice under dry weather and storm conditions determines (1) the float travel, (2) the closure of the gate and (3) the transmission ratio. The size of orifice is readily adjustable so as to correct any small divergence from the theoretical Q.

The 7 percent plus or minus variation used above is the average although sometimes this percentage is as small as 5 or as large as 10. This type of control is accomplished entirely by tail water.

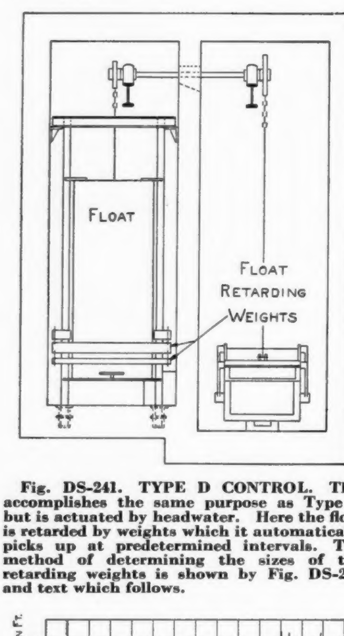
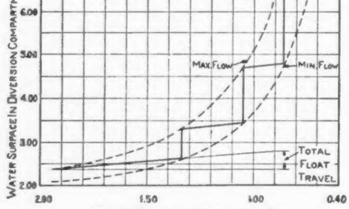
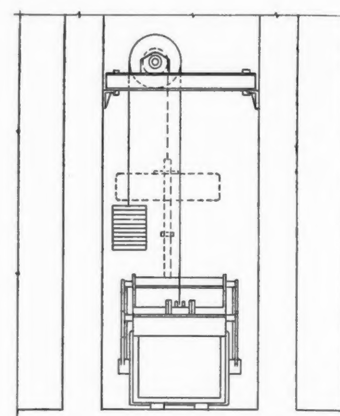


Fig. DS-241. TYPE D CONTROL. This accomplishes the same purpose as Type C but is actuated by headwater. Here the float is retarded by weights which it automatically picks up at predetermined intervals. The method of determining the sizes of the retarding weights is shown by Fig. DS-244 and text which follows.

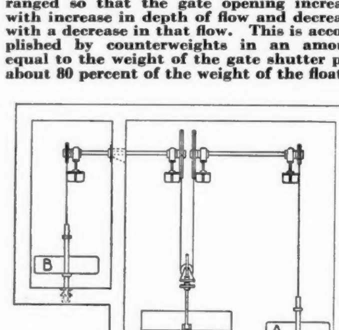


First determine several areas of gate opening at various heads for Q plus 7 percent and plot a "max. flow" curve. Next, proceed in the same manner and establish the "min. flow" curve. The float must be actuated between these two curves. Then, start at the low point on the max. flow curve and draw a tangent to that curve and continue it as indicated. From the point of intersection with the min. flow curve draw a vertical line to the intersection of the max. flow curve. From this intersection draw a line parallel to the first tangent until it intersects the min. flow curve. Continue this operation until a vertical line is located that does not intersect the max. flow line. The vertical lines indicate the intervals during which the float must be stopped in its travel; the parallel lines indicate the intervals when the float must travel with the water. The total float travel is the distance measured directly below the last vertical retarding line and is the distance between the tangent line and a horizontal line drawn through the P. C. of the tangent line.

This type of control requires a float of such depth that it will not be submerged under maximum storm conditions. Occasionally a problem requires a float of little depth so that the retarding weights may be made seatable on the top of the float. Such possibilities simplify structural conditions materially.



DS-236. TYPE E CONTROL. Occasionally, although rarely, it is required that a regulator operate in a way directly opposite to the usual method, i. e., the assembly is arranged so that the gate opening increases with increase in depth of flow and decreases with a decrease in that flow. This is accomplished by counterweights in an amount equal to the weight of the gate shutter plus about 80 percent of the weight of the float.



DS-237. TYPE CB CONTROL. This is a dual type of control in that the regulator operates normally as Type C and within close limits governs the specified diversion to interceptor. Occasionally flood conditions in fresh water outlets make it advisable to close the regulator gate completely and pass all flow to fresh water. During normal condition of flow this regulator operates distinctly as Type C and is controlled by float "A". When flood in fresh water reaches a predetermined level float "B" becomes actuated and the regulator gate closes and float "A" settles down to its inactive position and the regulator gate remains closed until flood water recedes.

BROWN & BROWN, INC.

LIMA OHIO, U.S.A.

TIDE-GATES

CIRCULAR and RECTANGULAR

Fig. B-68 Sizes Available						
4"	6"	8"	10"	12"	15"	18"
20"	24"	30"	36"	42"	48"	54"
60"	66"	72"	78"	84"		

Figure B-68. Type M (Circular) Tide Gate arranged for mounting on vertical wall faces.

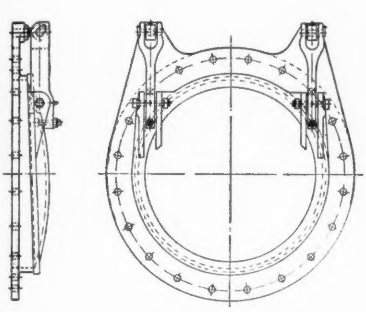


Fig. 9142 Sizes Available						
4"	6"	8"	10"	12"	14"	16"
18"	20"	24"	30"	36"	72"	

Figure 9142. Type M Tide Gate arranged with C.I.P. back flange for use with standard flanged pipes. Back flanges may be drilled either to 25 or 125 template.

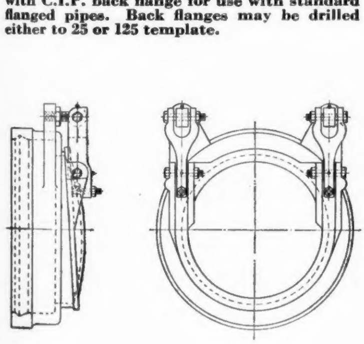


Fig. 9140 Sizes Available						
6"	10"	12"	18"	24"	30"	36"

Figure 9140. Type M Tide Gate arranged with standard C.I.P. bell back end for mounting on standard beaded spigot ends.

Fig. B-175 Sizes Available						
4"	6"	8"	10"	12"	14"	16"
18"	20"	24"	30"	36"	42"	48"
54"	60"	66"	72"	78"	84"	

Figure B-175. Type M-R Gates designed especially for application to centrifugal pump discharge lines. A rubber seating ring is inserted in the seat to absorb the slap which occurs when pumps stop. A flexible bar connection is arranged between the hinge links to provide a stop for the gate shutter to prevent the outer edge of the shutter from tipping downwardly when flow abruptly ceases. Smaller sizes of gate are provided with a bumper arrangement to prevent the shutter being forced too widely open when flow starts.

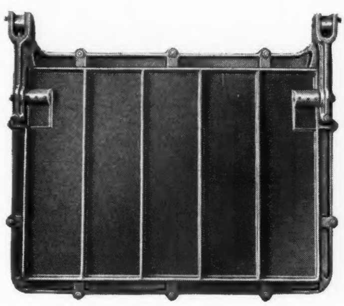


Fig. B-61 Sizes Available			
H x W	H x W	H x W	H x W
8" x 8"	24" x 24"	42" x 42"	60" x 42"
8" x 12"	24" x 36"	42" x 63"	60" x 60"
12" x 12"	24" x 48"	48" x 32"	60" x 72"
12" x 18"	30" x 20"	48" x 36"	60" x 96"
12" x 36"	30" x 24"	48" x 48"	66" x 48"
15" x 15"	30" x 30"	48" x 54"	72" x 48"
15" x 22½"	30" x 45"	48" x 60"	72" x 60"
18" x 12"	36" x 24"	48" x 72"	72" x 72"
18" x 18"	36" x 36"	48" x 84"	96" x 96"
18" x 27"	36" x 48"	54" x 26"	
24" x 12"	36" x 54"	54" x 36"	
24" x 16"	42" x 28"	54" x 54"	

Figure B-61. Type M-M (Rectangular) are arranged for attaching to vertical wall faces.

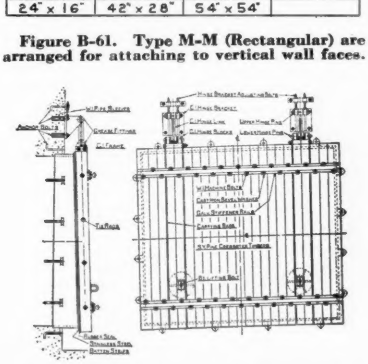


Figure 9320. Type M-M-T (Rectangular-Timber) Tide Gates are intended to extend into sizes larger than available in the type M-M, Figure B-61 Gates.

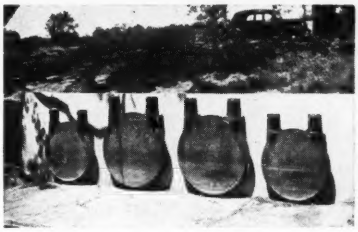


Figure B-54. Two 72" and two 60" Type M Tide Gates on Fall Creek, Marion County, Ind.

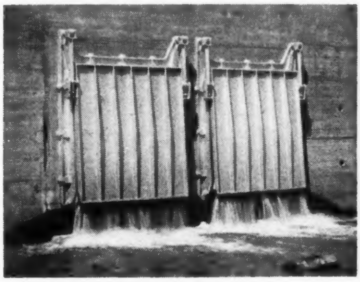


Figure B-124C. Two 72"x72" Type M-M Gates on Toby Creek Outlet Works, Edwardsville, Pa.

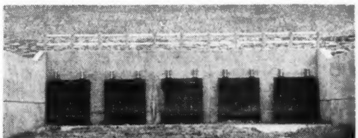


Figure B-138. Five 96"x96" M-M-T Gates on Brown Creek Outlet Structure, Plymouth, Pa.

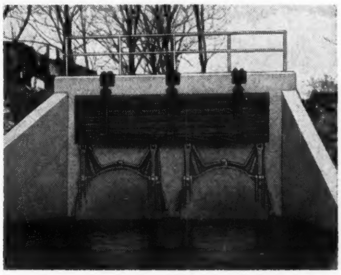


Figure B-170A. Two 72" Type M and one 30" high x 156" wide M-M-T Gates on Outlet structure, Wilmington, Del.

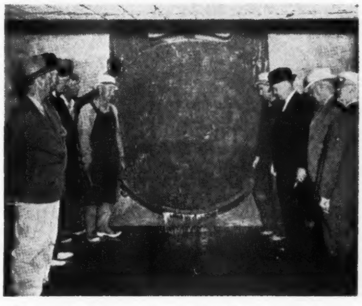


Figure B-178. 72" Type M Gate, Ft. Wayne, Ind.

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Non ASCE Meetings

American Concrete Pressure Pipe Association. Seventh annual meeting at the Inn, Rancho Santa Fe, California, October 19–24.

American Society of Mechanical Engineers. Diamond Jubilee 75th Anniversary Annual Meeting at the Congress, Conrad Hilton, and Blackstone Hotels, Chicago, the week of November 13.

American Standards Association. Sixth National Conference (co-sponsored by the National Bureau of Standards) at the Sheraton Park Hotel, Washington, D.C., October 24–26.

Atomic Industrial Forum. Peacetime atomic energy exposition, sponsored jointly by the Atomic Industrial Forum, the Fund for Peaceful Atomic Development, and the Carnegie Endowment for International Peace, at Carnegie Endowment Center, United Nations Plaza, 46th St. and First Ave., October 20–November 3. Information from Dan Scherer, AIF, 260 Madison Ave., New York 16, N.Y.

Chicago Exposition of Power and Mechanical Engineering. Under the auspices of the ASME, at the Chicago Coliseum, November 14–18. Details from CEPME, 480 Lexington Ave., New York 17, N.Y.

Chi Epsilon. New York alumni chapter's annual luncheon at New Campus Restaurant, 106 W. 32nd St., on October 27 at 12 noon during the Annual Convention of ASCE.

Engineers Joint Council. Nuclear Engineering and Science Congress and Atomic Exposition (sponsored by the American Institute of Chemical Engineers) in Cleveland, Ohio, December 12–16. Information from EJC, 29 W. 39th St., New York 18, N.Y.

Institute of Traffic Engineers. Silver Anniversary Meeting at the William Penn Hotel, Pittsburgh, October 23–27. Information from Chairman M. J. Gittens, City-County Building, Pittsburgh 19, Pa.

National Council of State Boards of Engineering Examiners. Thirty-fourth Annual Meeting at the Sheraton-Park Hotel, Washington, D.C., October 20–22. Information from T. Keith Legare, P. O. Drawer 1404, Columbia, S.C.

Primer Congreso Mexicano de la Industria de la Construccion. First Mexican Congress of the Building Industry and the First Industrial Building Exhibit in Mexico City, November 7–11. Information from PCMIC, Paseo de la Reforma 133–6th piso, Mexico 4, D.F.

Society of American Military Engineers. Dinner dance, Waldorf-Astoria Hotel Ball Room, October 22 at 8 p.m. Maj. Gen. Glen E. Edgerton will speak on "Importance of Canals in World Trade." All ASCE members are welcome. Make reservations with Herbert P. Flaherty, Assistant Secretary, New York Post of SAME, 346 Broadway. Phone WO 2-7520.

Society for Experimental Stress Analysis. Annual meeting at the Hotel Sheraton, Chicago, November 16–18. Information from W. M. Murray, Secretary-Treasurer, SESA, P.O. Box 168, Cambridge 39.

Southeastern Association of State Highway Officials. Annual meeting in Charleston, West Va., October 17–19. Information from Louis E. Keefer, Chairman, Publicity and Advance Information Committee, 1800 Washington Street, E., Charleston 5.

Structural Clay Products Institute. Annual convention at the Greenbrier Hotel, White Sulphur Springs, West Va., October 31 and November 1–2. Information from SCPI, 1520 18th St. N.W., Washington 6, D.C.

Society of Automotive Engineers. Golden Anniversary Transportation Meeting at the Chase Hotel, St. Louis, Mo., October 31–November 2. Information from SAE, 29 W. 39 St., New York 18, N.Y.

Wire Reinforcement Institute. Annual fall meeting at The Inn, Ponte Vedra Beach, Fla., October 31–November 2. Information from Frank B. Brown, Wire Reinforcement Institute Inc., National Press Building, Washington 4, D.C.

What's New in Skyscrapers . . .

(This article begins on page 65)

(Continued from page 69)

his forces. Expeditious completion or floundering depend upon the thoroughness and wisdom of his master strategy. The successful contractor now uses trained engineers, with their broader outlook and comprehension, to supervise and manage the construction operation.

As to cost, the modern office building is much more expensive than buildings constructed 25 years ago. This is due not only to the decrease in the value of the dollar, but also to the much increased mechanical facilities and comforts demanded in these buildings. As an indication of the change that has taken place in these categories, the average cost of the heating, ventilating and air conditioning, plumbing and electrical work today amounts to about 35 per cent of the total expenditure. This contrasts with about 20 percent 25 years ago. We believe there is still great value in the building dollar.

Looking ahead

Manufacturers, architects, engineers and builders are, through conferences and carefully prepared papers, recording and interpreting research findings, working toward progress on an industry-wide basis. The now established trend toward lighter weight in materials, prefabrication, and mechanical conveniences in skyscraper construction will continue.

Greater attention to pre-planning study with the owner will make it possible to meet the problem more squarely. A well organized program will facilitate the work of the architect, resulting in less waste in planning manpower and indirectly in a cost saving to the owner.

Vertical transport will become faster through increased automatization. Distribution of energy and air will be made in pre-formed parallel ducts or cellular floors forming a part of the structure.

Modular floor space systems will increase efficiency in area use. Simplified sealed skins, faster construction through less lost motion in manpower, and improved professional cooperative effort, will continue to increase the value of the building dollar.

Architects will use more brilliant and varied exterior colors. With a gayer mood in demand, the soot-covered facade will have the obsolescent appearance of a pre-smoke-control factory.

Efficiency, comfort, and mechanical elegance will be the handmaidens of the skyscraper office building of tomorrow.

Industrial waste treatment . . .

(This article begins on page 96)

(*Continued from page 103*)

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(End)

More efficient sewage treatment . . .

(This article begins on page 110)

(*Continued from page 112*)

As a rule sewage-treatment works are well designed. The great difficulty has been to obtain adequate appropriations for their operation and maintenance after they are put in service. This condition has frequently resulted in inadequate maintenance of plant equipment and in the inability to secure a sufficient number of well trained personnel. No easy solution of the problem seems possible. One difficulty has been that private industry pays much higher salaries to technically trained men.

Since the public bears the expense of sewage-plant operation and maintenance, it would seem that the best long-range plan for securing suitable appropriations for plant operation is to educate the public in every way possible regarding the importance and the intricacies of sewage treatment. If such an educational program is persistently followed, the taxpayer will become more familiar with the problems confronting the sewage-plant operator and will be more willing to see that adequate appropriations are allotted for plant operation and maintenance.

The sanitary engineer is better able today than ever before to design, construct, and operate sewage treatment plants. He has a better understanding of sewage treatment processes than he had 25 years ago and has more ways of solving problems relating to the treating of municipal sewage. Although the cost of constructing sewage treatment plants has greatly increased since the Second World War, this increase has been compensated for, at least in part, by the ability to design more efficient treatment units. Furthermore, a more exact knowledge of materials of construction and of the design of structures is reflected in considerable economies.

Sanitary engineers are more competent than any other group to formulate the procedures necessary in order to maintain the purity of our lakes and watercourses. They should give freely of their knowledge when broad public policies are being discussed and adopted. The watercourses of a nation should be put to as wide a use as possible. In many instances the uses are in conflict, as when a river is used to dispose of sewage-plant effluent and at the same time for recreational purposes or as a source of water supply. Although the interests of the individual or group should be protected, that method of utilizing the resources of a watercourse will be the best which permits the greatest benefits.

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Men Available

CIVIL ENGINEER; J.M. ASCE; M.C.E.; P.E., New York; young; married. Five years' experience in hydraulic, sanitary, reinforced concrete, and airfield design, specification writing, and field work. Desires responsible position with consultant or construction firm. Location, New York City or vicinity. C-80.

CIVIL ENGINEER; A.M. ASCE; 30; married; BSCE; graduate work, 1948; ten years' diversified experience as chief operating, maintenance engineer; design, construction and operation of petroleum plants, warehouses, utilities, waterfront facilities. Has worked in U.S., Far East, Middle East, and South America; will relocate in U.S. or elsewhere. Desires permanent location with managerial responsibility. C-81.

SOILS ENGINEER; J.M. ASCE; 29; married; BCE, Cornell University. Five years' experience in major earthwork, airport, and hydro-development projects. Desires sales engineering position utilizing heavy-construction background. Willing to relocate and travel. C-82.

CIVIL ENGINEER; J.M. ASCE; BSCE; 24. Two years' experience in airfield design and construction both overseas and in U.S., while serving as officer in Corps of Engineers. Will be released in November. Has also supervised operation of hot-mix asphalt plant. Location desired West or Midwest. C-83-300-Chicago.

SANITARY ENGINEER; J.M. ASCE; A.B., M.S.; 31. Two years' plant operating shift engineer; one year on investigations and reports; four years' progressive design work on sewage-treatment works, sewers, etc. Location desired, northern Midwest. C-84-303-Chicago.

CIVIL ENGINEER; J.M. ASCE; 32; married; BSCE, 1949; registered civil engineer. Six years' progressive professional experience. Four years in highway engineering, field surveys and office design work. Two years in all phases of municipal enginnering, including street improvements, assessment districts, and sewers. Desires responsible position in San Francisco or adjacent areas. C-85-828-SF.

ASSISTANT PROFESSOR; A.M. ASCE; 43; married; ten years' experience in teaching structures, surveying, mechanics, etc.; ten years' experience in structural design, surveying, and construction; licensed professional engineer and land surveyor; desires position as professor, associate professor or design engineer with consulting firm. C-86

Positions Available

CIVIL ENGINEER experienced in design and preparation of specifications for earth dams and appurtenances. Location, Ohio. W-1935.

MUNICIPAL ENGINEER, young, for public works department of small community. Position will involve water works, sanitation, roads and highways. Location, eastern New York. W-1946.

SANITARY ENGINEER experienced in design and preparation of plans and specifications for water and sewerage plants. Permanent position. Location, southern Florida. W-1951.

GENERAL MANAGER for large construction company; ten to fifteen years' experience in refinery and chemical plant design and construction. Salary open. Location, East. W-1958.

ENGINEERS: (a) Civil Engineers, experienced in the design, preparation of plans, and supervision of construction of municipal water works, consisting of distribution systems and water-filtration plants, etc. (b) Sanitary Engineer to design and prepare plans for sanitary sewer systems and sewage-treatment plants. Salaries open. Location, New York State. W-1963.

DESIGN ENGINEER, civil, with four to six years' experience on reinforced concrete and structural steel design, on industrial buildings; some experience on waterfront construction also necessary. Salary, $6,000 a year. Location, New York, N. Y. W-1983.

OFFICE AND FIELD ENGINEER, civil graduate, with field engineering experience taking samples of underwater borings, quantity estimates and preparation of job drawings. Domestic and foreign trips. Salary, $6,500 a year. Headquarters, New York, N. Y. W-2009.

CIVIL ENGINEER, 30-45, graduate, for consulting engineering firm specializing in bridge and

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Construction Engineer, 30–40, civil graduate, with estimating and building construction experience for office and field duties with financial institution. Salary, $6,000–$8,000 a year. Location, New York, N. Y. W-2065.

Structural Designer, civil graduate, with at least ten years' design, layout and specifications covering industrial buildings. Salary, $8,000–$8,500 a year. Location, New York, N. Y. W-2073.

Construction Engineers, graduates. (a) Resident Engineer for airfield construction. Experience required in stabilization of compressible subsoils. Salary, $7,920–$9,360 a year. (b) Materials Engineer with wide experience in soil mechanics and working knowledge of concrete and asphalt. Salary, $7,920 a year. (c) Materials Engineer with experience in concrete and soils. Salary, $5,400 a year. Free housing. On all positions, transportation provided for employees and families. Contract 18 to 24 months depending on location. Living costs comparable to United States. Schools with American teachers. Location, Caribbean Area. F-2076.

Assistant City Engineer, civil, under 50, P.E., with experience in construction and design. Civil Service tenure. Salary, $7,740–$8,688 a year. Location, Michigan. W-2102-D.

Estimator, civil graduate, with field engineering and estimating experience on bridges, foundations and general heavy construction. Salary, $6,000–$8,500 a year. Location, western Pennsylvania. W-2108.

Senior Hydraulic Engineer for study and engineering work on hydroelectric, development, and maintenance of hydraulic structures. Must have minumum of 20–25 years' experience in this line of work. Salary open. Location, Far East. F-2112.

Superintendent, with heavy construction or subway experience, for open-cut tunnel project including underpinning of buildings. Salary, $9,100–$10,000 a year. Location, eastern Massachusetts. W-2125.

Structural Designer, civil graduate, with construction and equipment experience, to design foundations, industrial buildings, supports, etc. Salary, $4,800–$7,200 a year. Location, northern Texas. W-2131(b).

Construction Engineer, civil graduate, with at least 18 months' design and field engineering experience in heavy construction or industrial building fields. Salary, $5,440 a year. Location, Connecticut. W-2134.

Professor, mechanical graduate, with teaching experience in general mechanical engineering, including applied thermodynamics and machine design. Location, Near East. W-2138(b).

Engineers. (a) Construction Managers, experienced, to take charge and handle the construction of a large paper mill. Must have extensive experience in the construction of major and modern paper mill. (b) Project Managers, experienced on the construction of steam electric generating plants. Location, South. W-2142.

Teaching Personnel. (a) Professor, 35–45, M.S. degree desirable, but not essential, with teaching and professional experience in civil

(Continued on page 164)

ENGINEERING OPPORTUNITIES

For young graduate Civil Engineers interested in future as highway design engineers. Training under competent highway specialists in expanding well-established firm.

Permanent positions now available. Some highway experience preferred but not required.

Excellent starting salaries, moving allowance, Blue Cross, paid vacations and holidays; sick leave, and voluntary employee benefit and retirement plan.

Write for application form.

SVERDRUP & PARCEL
ENGINEERING CO.
1134 Locust St. St. Louis 1, Mo.

SOUTH DAKOTA DEPARTMENT OF HIGHWAYS
announces openings

Openings on the South Dakota Department of Highways staff present permanent opportunities for recent Civil Engineering graduates and experienced engineers in the following classifications and salary brackets:

Structural Designer 6240–7020
Structural Draftsman 6240–7020
Urban Design Engineer 6240–7020
Final Plans Draftsman 6240–7020
Soils Research Tech. 6240–7020
Soils Engr. Ass't. 5420–6340
Ass't. Engineer-Geologist 4800–5420
Civil Engineers (Highway-Survey-Design-Construction) 4800–8040

These openings offer sick leave with pay, paid vacations, military leave with pay, available hospitalization plan.

Write to: H. A. Tunge, Personnel Director, Department of Highways, Pierre, South Dakota. Application forms will be forwarded by return mail.

Men and Jobs Available

(*Continued from page 163*)

engineering, to handle undergraduate subjects in at least two subdivisions of civil engineering. (*b*) Assistant Professor, at least 25, with minimum of two years' experience in either teaching or engineering practice, to teach civil engineering subjects. Salaries open. Location, foreign. F-2151.

SALES ENGINEERS, 27–35, civil graduate, with concrete experience, for technical field work with customers of cement manufacturer. Salary, $4,800–$6,000 a year. Location, Northeast. W-2165.

Applications for Admission to ASCE, Aug. 13–Sept. 3, 1955

Applying for Member

CARL JOHN ALSTER, Washington, D.C.
ERHARD EHRENFRIED DITTBRENNER, Albany, N.Y.
WILBUR GILLFILAN GUILD, Chicago, Ill.
HERBERT CRAMER HARTMAN, Jersey City, N.J.
RAY EWALL HILL, Pearl Harbor, Hawaii.
THEODORE HOOD, New York, N.Y.
RICHARD LEE HUNT, Urbana, Ill.
LAMAR CANTELOU LEBRON, Wilmington, Del.
CHARLES ERIC MERGENTIME, Detroit, Mich.
CLARK WILLIAM PENNINGTON, Gainesville, Fla.
ROBERT JAMES RALPH PUNDT, Miami, Fla.
GEORGE DEWEY REYNERTSON, Chicago, Ill.
JAMES EDMUND SOWER, Cincinnati, Ohio.
BOBBIE MILTON TANNER, Patrick Air Force Base, Fla.
COURTNEY SCOTT TROSPER, Roanoke, Va.
WILLIAM EMERY WAGNER, Denver, Colo.
ERNEST KENNETH WALKER, JR., Alhambra, Calif.
GALE BRUCE WHITE, Seattle, Wash.
CEDRIC WILLSON, Dallas, Tex.
THOMAS WESLEY YOUNG, Lincoln, Nebr.

Applying for Associate Member

GEORGE CLINTON BESTOR, Carmel, Calif.
ROBERT MARION BRACKIN, Greenville, Ala.
JOHN PURVIS BULMAN, London, England.
ROBERT D. CONNER, Massena, N.Y.
WILFRED WAECHTER DAVIES, San Carlos, Calif.
FRITS HAUCH FENGER, San Francisco, Calif.
ROBERT WALTER FRITZ, Montgomery, Ala.
ARCHER BAILEY GAY, Richmond, Va.
JOSEPH SEJOURNE GUERIN, Port-au-Prince, Haiti.
RALPH JAMES HEWLETT, JR., Lynchburg, Va.
RAYAPATI CYRIL HUBERT, Andhra State, South India.
HOWELL TILFORD HUNT, Los Angeles, Calif.
MILO KARL KEITH, Long Beach, Calif.
CHARLES ALEXANDER LEATH, Columbia, S.C.
THOMAS EDWARD MCGOWAN, Detroit, Mich.
GEORGE STUART MENZIES, Samarra, Iraq.
JACK LEE MEYER, Miami, Fla.
CHARLES CARL MODESETT, Freeport, Tex.
WILBUR ORMAND NELSON, JR., Baltimore, Md.
EDWARD SUMNER OLCOTT, New York, N.Y.
WILLIAM STEVENS PATTERSON, Roanoke, Va.
AUSTIN ALLEN RICE, Ventura, Calif.
LESTER MARTIN RIECHMAN, Jefferson City, Mo.
SEDAT SAMI, Nallihan-Baraj, Turkey.
WILBUR DOUGLAS SIMONS, Tacoma, Wash.
JULIUS BELDWIN SMOAK, SR., Shreveport, La.
DOUGLAS EUGENE SOPER, El Paso, Tex.
HARRY EUGENE STEMAN, Baltimore, Md.
ROSCOE CHARLES TATE, Atlanta, Ga.
FRANK HENRY THEROUX, Los Angeles, Calif.
VERNON SHUI FONG TYAU, Oahu, T.H., Honolulu.
WALTER ARTHUR WEBSTER, Albuquerque, N. Mex.
STRATY ZERVAKOS, Hyattsville, Md.

Applying for Junior Member

MICHEL SHAHIN ABU-JAWDEH, Beirut, Lebanon.
RALPH WILLIAM BOOKER, St. Louis, Mo.
JAMES RAMSEY BOWMAN, St. Louis, Mo.
HENRY LYNN COOK, JR., Olympia, Wash.
MARK HENNINGER CORBYN, Chicago, Ill.
HAROLD THOMAS EASTWOOD, W. Va.
MAX HENRY FOLEY, New York, N.Y.
ROBERT DONALD GRANT, Santa Ana, Calif.
CHARLES RUSSELL GRAY, St. Louis, Mo.
SATYANARAYAN PRASAD GUPTA, Urbana, Ill.
MELVIN JONES, Modesto, Calif.
ROBERT IRVING KAUFMAN, Vickburg, Miss.
JAMES DONALD LEACH, Berkeley, Calif.
SAMUEL WADE SHAFER, Cincinnati, Ohio.
THOMAS BUSHONG TERPENING, Jacksonville, Fla.
ALFONSO ZAVALA, Lima, Peru.

[*Applications for Junior Membership from ASCE Student Chapters are not listed.*]

663,936 lbs. flooring deadweight

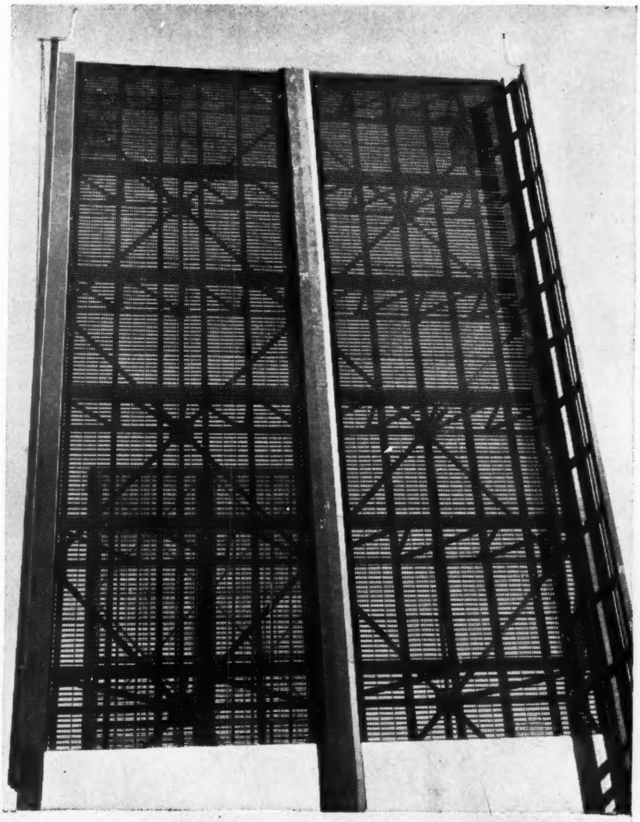
long, wide double-leaf bascule span

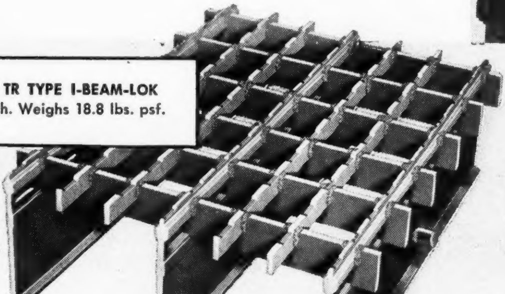
■ The 193'6" double-leaf bascule span on the four-lane Gilmore Street Bridge across the St. Johns River, at Jacksonville, Florida, provides another good example of the advantages of I-Beam-Lok lightweight steel flooring for structures of this type.

The total amount of USS I-Beam-Lok laid on the 55'11" roadway of the two bascule leaves is 10,677 sq. ft. of which 9,535 sq. ft. is the 5-inch open type flooring. The remaining 1,142 sq. ft. is the 3-inch concrete-filled type used in the part of the bascule leaves over the machinery.

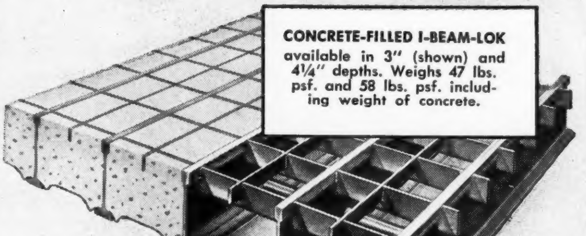
If conventional 7" concrete slab flooring (weighing 84 lbs. psf. as against 18.8 lbs. psf. for 5" open I-Beam-Lok and 47 lbs. psf. for 3" concrete filled I-Beam-Lok) had been used on this project, the floor of the long, wide double-leaf span would have had a deadweight of 896,868 pounds. *Four times greater than its present light 232,932 lbs. deadweight!* In addition, the heavier flooring would have increased the wind resistance of the span, and made necessary the installation of costlier, more powerful mechanical equipment to raise and lower the heavier bascule leaves of the span.

USS I-Beam-Lok is the modern floor for modern traffic. It combines lightweight and ensuing reduced costs with roadway rigidity, ease of erection, a smooth, hard surface and low maintenance costs. It is available in both open and concrete-filled types. Our engineers will be glad to discuss its possibilities with you. Just contact the sales office nearest you.





OPEN TR TYPE I-BEAM-LOK
5" depth. Weighs 18.8 lbs. psf.



CONCRETE-FILLED I-BEAM-LOK
available in 3" (shown) and 4¼" depths. Weighs 47 lbs. psf. and 58 lbs. psf. including weight of concrete.

AMERICAN BRIDGE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS I-BEAM-LOK

UNITED STATES STEEL

CATALOG DIGESTS of ENGINEERING and INDUSTRIAL interest

1 AERIAL MAPPING

Aero Service Corporation—Offers catalogs or literature covering new and more economical applications of varied aerial mapping services. These include aerial photography, topographic and planimetric maps from an aerial photographic base, precise aerial mosaics, airborne magnetometer surveys for ore and oil, and both plastic and plaster relief maps. Services discussed are used in highway design, plant engineering, industrial development, community planning.

2 AERIAL SURVEY AND MAPPING METHODS

Fairchild Aerial Surveys, Inc.—Aerial survey and mapping methods, particularly in relation to engineering and planning problems, are described and illustrated in "Focusing on Facts," available when requested on your business letterhead.

3 AERIAL SURVEYS

Hycon Aerial Surveys—Has published a sixteen page booklet in color describing its services of photogrammetric engineering and mapping service. Aerial surveys can map large areas, quickly and inexpensively, and the result is better planning, and more accurate evaluation. Hycon is invaluable in solving the problems of city planning, highway and railway location and helping in the discovery of natural resources, as well as having many other uses. Photomaps and topographic maps enable surveyors, geologists, engineers, and others to search thousands of square miles while seated in an office. Thus thousands of man-hours are saved by sending ground crews only to the most likely locations as revealed first by precision aerial surveys.

4 ALTIMETER SURVEYING

Wallace & Tierman Inc.—Multiple base altimetry produces higher accuracy than "text book" methods and permits using surveying altimeters at times which were previously considered unsuitable from the standpoint of meteorological conditions. This new concept of altimeter surveying is described in a technical paper entitled, "Improving the Accuracy of Altimetry."

5 AMSEAL JOINTS FOR CONCRETE PIPE

American-Marietta Company—Illustrated folder covers the various uses for Amseal—"A Pressure Proven Joint" furnished on low pressure concrete pipe. Blueprint and drawing show construction features. Specifications and basic dimensions are given for pipe and joints. Photos show fabrication methods and installations of concrete pipe with Amseal Joints.

6 AUGER DRILLS

The Salem Tool Company—Earth and rock boring auger drills are described in Bulletin M-105. Features of horizontal blast hole drills are explained, as are the following features of truck-mounted and self-propelled drills: power unit, transmission, main drive case, carriage, main frame, hydraulic unit and elevating jacks.

7 BELT CONVEYORS

Barber-Greene Company—Catalog 76-A (192 pages) describes a complete line of standardized, heavy duty belt conveyors for aggregates, coal, ore, mining use and general materials handling. Over 70 pages are devoted to job photographs and installation layout drawings. Each category of conveyor components, drives, truss, terminals, accessories is treated separately with complete descriptions and specifications. An additional section gives engineering layout tables and specifications of various materials to aid in determining capacities, and layout.

8 BILTON PUMPS

Byron Jackson Company—A four-page colored brochure, complete with selection table, performance chart and illustrations, describes the BJ Bilton pumps, type LL. These pumps are single stage, single suction with closed impeller. Small and compact, they can deliver 80 gallons per minute at 75 ft. head. Dewatering, small irrigation, building service, and cooling towers are only a few of their uses, which Bulletin 54-3-1005 describes.

9 BITUMINOUS BATCH PLANTS

Barber-Greene Company—Through the use of detailed drawings and diagrams, this 12-page, two color folder describes the revolutionary principles which contribute to the efficiency of Barber-Greene's newly announced Model 890 Bituminous Batch Plant series. The special aggregate and bitumen measuring systems are treated in detail, as is the theory and operation of the new "Dyan-Mix" pugmill.

10 BITUMINOUS CONSTRUCTION HANDBOOK

Barber-Greene Company—This is a complete pocket-size book on all phases of bituminous road and airport runway construction. It deals with all basic problems of bituminous construction: selection of materials, properties of bitumens and aggregates, mixing and laying procedures, etc. Now in its revised version, this handbook is an accepted text in many colleges of engineering and is a TM, used by armed forces engineering units. The cost of this book is $2.00.

N. B. There is a charge for this book. Make checks payable to Barber-Greene Company.

11 BITUMULS FOR BASE CONSTRUCTION

American Bitumuls & Asphalt Company—Offers a 12-page, two-color booklet, "Bitumuls for Base Construction," which is an illustrated and valuable guide on the modern methods and equipment for construction of stable, water-resistant bases for pavements. Various types of aggregates may be used, after proper laboratory classification in this method of construction.

12 BITUMULS FOR SURFACE COURSE MIXES

American Bitumuls & Asphalt Company—Offers a 12-page, two-color booklet, "Bitumuls for

CATALOG DIGESTS

Surface Course Mixes," which is a guide to the modern methods and equipment for construction of wearing surfaces for pavements. Amply illustrated, this booklet covers various methods, including valuable laboratory guides.

13 BOILERS AND STOKERS

The James Leffel & Co.—Bulletin 236 describes the most ruggedly built and reliable Scotch boilers capable of maximum performance and endurance, for oil, gas, or coal firing.

14 BORINGS

Raymond Concrete Pile Co.—A booklet "Subsoil Investigations for Foundations," Catalog B-5 explains the reason for subsoil investigations, what Gow borings are and how they are made, and the results obtained. Illustrated are methods for making borings and taking samples, and various types of rigs in operation.

15 BRIDGE PLANK

Armco **Drainage & Metal Products, Inc.**—A 16-page booklet which describes and illustrates Armco Bridge Plank. Design of product consists of 2-inch deep trapezoidal corrugations in 2-foot-wide steel planks, providing a firm base for smooth, bituminous traffic surface. Includes case histories, engineering details, design data, recommended installation practice.

16 BUILDER'S TRANSIT LEVEL

Charles Bruning Company, Inc.—A four-page folder describing the new Brunson Builder's Transit-Level is available. Featuring dust-proof construction, and patented ball bearings in telescopic axes, the Transit-Level assures lasting accuracy without frequent overhaul, adjustment, and repair expense. Model 65 gives the performance of an engineering instrument at a builder's level price.

17 CALIBRATED MEASURING WHEELS

Rolatape, Inc.—Widely used by paving contractors, utilities, land appraisers, and on preliminary survey work, Models 400 and 600 are especially designed for use on rough terrain and for long distances. Guaranteed for two years, the measuring wheels are light in weight, equipped with fold-a-way handles, stands to support the unit and a carrying case.

18 CAST IRON PIPE

U. S. Pipe & Foundry Co.—Offers an 8-page booklet on U. S. centrifugally cast Roll-On Joint pipe for water, sewage or other liquids. It contains a table of dimensions and weights and illustrations showing progressive steps in assembly of Roll-On Joint.

19 CAST IRON PIPE, HYDRANTS AND VALVES

R.D. Wood Company—A new general catalog has recently been issued providing full details of weights and dimensions of "Sand Spun" Cast Iron Pipe and Cast Iron Fittings. This catalog also features "Mathews Modernized" and R. D. Wood Fire Hydrants, R. D. Wood Gate Valves and other products manufactured by this company.

20 CEMENT GUN

Cement Gun Company, Inc.—Of considerable interest to the engineering profession is a 65-page booklet, designated as Bulletin 3000 describing the cement gun and its applications. It covers the principal uses of "Gunite" and is profusely illustrated. In the last few pages of this bulletin are typical specifications for various types of "Gunite" work.

21 CHEMICAL FEEDER

Proportioneers, Inc.—New Bulletin 1910-3 describes a low capacity chemical feeder known as the "Chlor-O-Mite." It is a compact electrically

and hydraulically operated diaphragm-type feeder. Specifically designed for controlled feeding of Hypochlorite or water treating chemical solutions into small water systems, operating at not over 25 gallons per minute and 50 pounds per sq in. pressure. All parts needed for the complete installation are furnished as a kit.

22 COAL RECOVERY DRILLS

The Salem Tool Company—Bulletin M-101, a 4-page, 2-color pamphlet describes coal recovery drills 16" to 42" in diameter for 6" augers. Photographed are a heavy-duty barrel-type drill head, 42" in diameter with tungsten carbide 3-prong pilot adjustable core burster, reinforced double auger flighting, barrel equipped with bug dust clearance spirals; and a 36 in. heavy-duty nut and slack drill head for drilling rock and producing nut and slack coal.

23 COFFERDAMS

Spencer, White & Prentis, Inc.—"Cofferdams," by Lazarus White and Edmund Astley Prentis is a trusted source-book covering actual design and construction of cofferdams as well as the theoretical features. The price is $10.

N.B. There is a charge for this book. Make checks payable to Spencer, White & Prentis, Inc.

24 COILFILTER

Komline-Sanderson Engineering Corp.—Has available bulletins on the Coilfilter, a modern vacuum filter. They describe how this filter is designed for modern sludge dewatering requirements. Outstanding features of the filter are defined as non-clogging, permanent filter media, constant output and low operating cost.

25 COMMERCIAL CATALOGS

Commercial Shearing and Stamping Company—Has available several leaflets describing their oil hydraulic controls, standard steel shapes, stampings and forgings, and oil hydraulic pumps, motors, and cylinders. Clear photographs illustrate representative items of each of these products and interesting sketches show their end use. Contents include details and data.

26 CONCRETE ADMIXTURES

Sika Chemical Corporation—Brochures describe Plastiment Retarding Densifier and Sikacrete Accelerating Densifier. Test data and specifications are included. Information on prestressed concrete, lightweight concrete, floating concrete structures, extra-duty concrete floors is also available.

27 CONCRETE BUCKETS

Gar-Bro Manufacturing Company—Lightweight buckets, with all welded steel construction, are self-closing and grout tight eliminating spillage of concrete. They travel through the air to deliver concrete to forms and require no scaffolds or ramps. Steep bowl construction assures quick, clean dumping without arching. Round and laydown buckets, and accordion hoppers are fully described with specifications.

28 CONCRETE FORMING SYSTEM

Economy Forms Corporation—A catalog with pictures is offered showing a complete forming system available to contractors on a purchase basis. The easy adaptability of these forms to all types of form work, plus engineering layout service on each new project, together with a complete steel form good for a lifetime of service makes the new EFCO form an attractive investment for the large and small builder.

29 CONCRETE PAVEMENT MANUAL

Portland Cement Association—This new 72-page illustrated manual gives details of geometric pavement designs and outlines the best methods of construction. It presents in summarized, usable form data on pavement layout and construction from recent technical society proceedings, engineering publications, field observations, tests and experience.

(Sent in U.S. and Canada only.)

30 CONCRETE PIPE FOR IRRIGATION AND DRAINAGE

American Concrete Pipe Association—An official publication is available to engineers. It contains information or design of irrigation pipe lines, construction of irrigation pipe lines, methods of irrigating with concrete pipe lines and descriptions of various irrigation projects. This book is priced at 70¢.

N. B. There is a charge for this book. Make checks payable to the American Concrete Pipe Association.

31 CONCRETE PIPE HANDBOOK

American Concrete Pipe Association—This handbook contains 384 pages on the manufacture and use of concrete and reinforced concrete sewer and culvert pipe. Discussion of Marston's Theory and maximum and minimum allowable depths of fill is presented along with examples and tables. A thorough comprehensive discussion of the use of concrete pipe in sewers and culverts is included. Appendix contains A.S.T.M. and AASHO specifications. Price $4.00.

N. B. There is a charge for this book. Make checks payable to The American Concrete Pipe Association.

CATALOG DIGESTS

32 CONCRETE SEWERS

Portland Cement Association—This 48-page booklet describes the advantageous use of concrete in sewer construction. The introduction includes a brief history of sewers and early use of concrete sewers. Others chapters are devoted to hydraulic and structural design and construction, maintenance and repair. It is well-illustrated with photos, charts, tables and graphs.
(Sent in U.S. and Canada only.)

33 CONCRETE TANK RESTORATION

Western Waterproofing Co. Inc. of Missouri—A well-illustrated folder describes services for maintenance and restoration of concrete storage tanks. Tells how to recognize concrete deterioration, explains what causes it and suggests a time-tested system for assuring lasting protection. Illustrations show examples of concrete elevators before, during and after restoration work.

34 CONVEYORS

Link-Belt Company—Trukveyors, a dragline conveying medium designed to reduce the unit cost of materials handling in warehouses, truck and railroad terminals, are described in detail in a 24-page illustrated book. Book 2497 describes both the overhead and in-the-floor types of Trukveyor.

35 COOLING TOWERS

Halstead & Mitchell—Specifications, both operating and mechanical, and design details of four basic types of cooling towers are included in Bulletin CT-584. Described are commercial, industrial, residential, take-apart and centrifugal fan cooling towers with discussion as to the suitability of application to each type. Cutaway views and line diagrams simplify interpretation of tabular material.

36 CORE DRILLING MACHINES

Sprague & Henwood—Announce the development of two new Diamond Core Drilling Machines: Model 30 and Model L-2, to meet the need for compact units which can be moved easily from one location to another and can also be relied upon to produce good smooth cores rapidly, up to moderate depths. Both models can be powered by either a gasoline or diesel engine, air or water cooled, an air motor or an electric motor. Normally skidmounted, they are available, also, with an improved type of two-wheel trailer mounting for easy portability. Illustrated leaflets describe other improved features and complete working data.

37 CRANE WEIGHT INDICATOR

Martin-Decker Corporation—Bulletin M-24 describes the new crane-weight indicator which enables the operator to know at all times the total weight of the load being lifted, and the lifting capacity of the crane at various radii. In addition the Indicator permits tallying lifts when loading trucks, thus preventing overload fines, and shows the reach of the boom when making blind lifts.

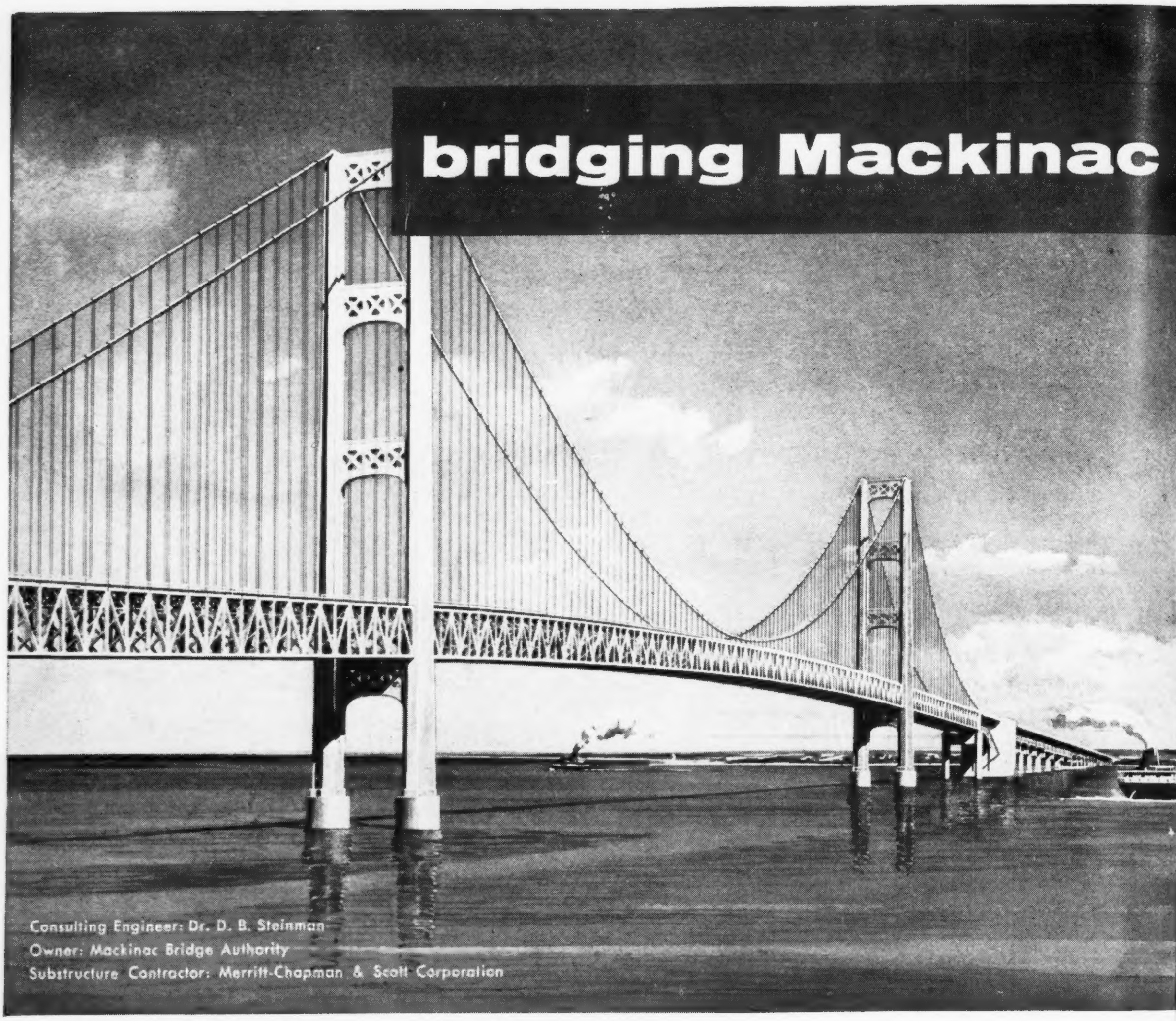
38 CRAWLER TRACTOR

Allis-Chalmers Manufacturing Company—Technical and operating story of Allis-Chalmers new HD-16 crawler tractor is incorporated in the two-color brochure includes pictorial review of design, engineering and operating advancements and specifications of the new model. The tractor has a rated 116 drawbar hp and 150 rated net engine hp with torque converter drive. The HD-16 with standard transmission weighs 31,500 pounds; with torque converter drive, 31,600 pounds.

39 DESIGN MANUAL

Barksdale Valves—"Design Handbook & Catalog," 52 pages, provides the means for proper selection of a pressure switch for your specific application. It contains step by step selection charts, a complete run down, illustration and tabulation of all the detail features—leading to the unit that solves the control problem.

bridging Mackinac .o



Designer's rendering of Mackinac Bridge, St. Ignace, Michigan. Total length: 26,444 feet.

A great new link in our national highway system, the Mackinac Bridge, will soon span the Straits of Mackinac and connect the two peninsulas of Michigan. Scheduled for completion late in 1957, this suspension bridge—the world's longest from anchorage to anchorage—will rest entirely on Prepakt Concrete. Some 440,000 cubic yards are being placed for the 34 foundation piers.

Prepakt was selected for this five-mile project because of its greater—

Economy. Savings result from the use of a smaller, more economical plant which need mix only the Intrusion Mortar. Coarse aggregate, over 60% of the total concrete volume, is placed directly into cofferdams by self-unloading boats. For the same reason, supply problems are simplified and placement can continue uninterrupted during rough weather. Finally, Prepakt Concrete with less cement content is of better quality than tremied concrete.

Speed. Rapid concrete placement by Prepakt's method has produced these new records for underwater placement from a single floating plant: 8-hr. shift—2,240 cu. yds.; 24-hr. day—6,250 cu. yds.; 5-day week—20,560 cu. yds.; 8-day period—28,320 cu. yds.; 30-day period—102,000 cu. yds.

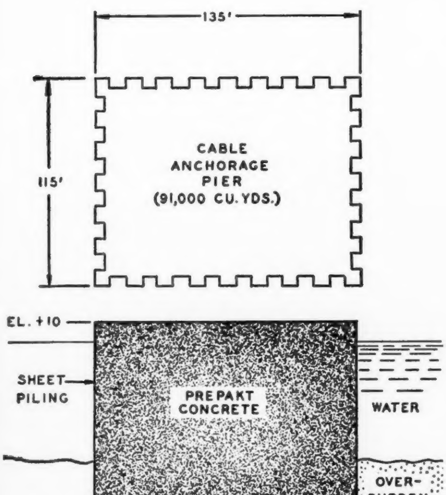
Flexibility. Prepakt Concrete does not require a continuous pour—placement can be halted and restarted on short notice at little added expense and with no sacrifice in quality. This proved a vital advantage during late 1954 when storms suspended operations repeatedly.

Mackinac Bridge will soon stand as another example of the multiple advantages of Prepakt methods and materials for all types of concrete structures. This $100-million bridge, believed for many years to be impractical if not impossible, is a tribute to its advanced design and the use of modern construction methods. A brochure describing the building of the Mackinac Bridge in greater detail is available upon request.

[*Intrusion* and *Prepakt* are trademarks of Intrusion-Prepakt, Inc. Intrusion-Prepakt methods and materials are covered by U.S. Pat. 2313110, 2655004, 2434302 and others, also patents pending.]

... on Prepakt Concrete

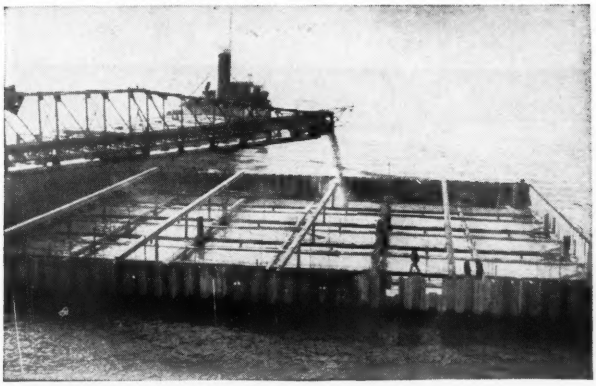
Prepakt method cuts cost of piers, sets new concrete placement records

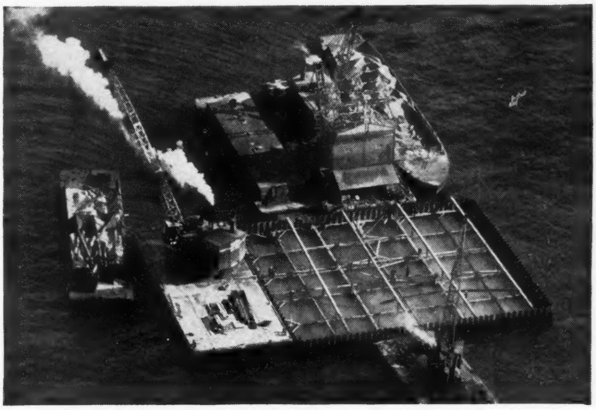


The 66,500-ton bridge superstructure is supported by 34 piers, some extending to more than 200 feet below the water surface. Concrete for these piers, made by Prepakt method of consolidating preplaced aggregate with Intrusion Mortar, was placed by the substructure contractor, Merritt-Chapman & Scott Corporation.

Almost all piers used cofferdams of interlocking sheet piling driven to bedrock. After removal of overburden, aggregate was then deposited into cofferdams from 10,000 to 15,000 ton self-unloading boats at rates up to 2,500 tons per hour. Final step was to consolidate stone with Intrusion Mortar which was batched, mixed and pumped from a Prepakt Floating Plant.

Use of the Prepakt technique introduced economies and kept the project on schedule despite the worst construction weather in many years.





(Top) Unloading stone directly into cofferdam for massive cable anchorage pier. (Bottom) During concreting operations, Prepakt Floating Plant is tended by cement-Alfesil barge (left) and sand barge (right).

Prepakt maintains a complete field construction organization plus an engineering service and functions as prime or subcontractor. For further information, write: The Prepakt Concrete Co., Room 779-Y, Union Commerce Building, Cleveland.

CONTRACTORS · PREPAKT® · ENGINEERS

THE PREPAKT CONCRETE CO.
DIVISION OF INTRUSION-PREPAKT, INC.

MAIN OFFICE: CLEVELAND 14, OHIO
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STOCKHOLM · HELSINKI · LONDON · TOKYO · HAVANA

CATALOG DIGESTS

40 DESIGN OF CONCRETE AIRPORT

Portland Cement Association—This 48-page booklet on the design of concrete pavement for airports presents design charts for determination of pavement thickness and concrete resurfacing. Also included are recommendations for jointing layout, the use of sub-base under concrete and the evaluation of existing pavements.
(Sent in U.S. and Canada only.)

41 DRAFTING MACHINES

V. & E. Manufacturing Co.—Has issued a new 15-page brochure giving detailed descriptions of such drafting machines as the Vertical Drafter, Detail Drafter, Left-Handed Drafter, and Formed & Solid Drafting Machine Scales. Information on how to select the proper size machine will be helpful to engineers and draftsmen. Also included is a price list.

Turn to page 168 and order your literature.

42 DRAIN GRATES

Irving Subway Grating Co., Inc.—A recently published 4-page, two-color folder illustrating the use of open mesh steel flooring as drain grates is now available. The folder contains photographic illustrations and shows typical uses of drain grates (as much as 90% open). There are engineering drawings of the various types and complete technical data to facilitate estimates and specifications.

43 DRAWING INSTRUMENTS

V. & E. Manufacturing Co.—Has published a booklet describing their various drawing instruments and drawing sets. Among the instruments included are Open-Truss Compasses, Drop Bow Compasses, Friction Dividers, Vemco Velox Beam Compasses, Erasers, and Drawing Leads. A price list is also given.

44 DRAWING MATERIALS

The Eberhard Faber Pencil Co.—Has recently published a four page catalog in full color, which pictures their complete line of drawing materials developed for use in the design or drafting room. This includes pastels, colored pencils, drawing pencils, leads and holders, erasers of every type and a host of other related items.

45 DRILLERS SUPPLY CATALOG

Acker Drill Co., Inc.—Bulletin 50 indexes, illustrates and describes over 150 drilling tools and accessories. For reader convenience, the Catalog is divided into 7 sections, each of which are devoted to specific drilling subjects.

46 EARTHMOVING EQUIPMENT

Wooldridge Manufacturing Div.—Bulletin No. TH-951 gives information and pertinent specifications on Terra Cobra Model TH-090B, self-propelled Scraper, together with information on other Wooldridge earthmoving equipment.

47 EARTHMOVING EQUIPMENT

Wooldridge Manufacturing Div.—General Catalog gives pertinent specifications and descriptive material on Wooldridge earthmoving equipment.

48 ELECTRONIC FISH CONTROL

The Electric Fish Screen Company—Offers an illustrated pamphlet describing a new design in Electronic Pulse Generators, used in connection with their Electric Fish Screens. This equipment requires virtually no servicing, and its operation is entirely automatic. It is not sensitive to weather conditions, and can be adjusted to compensate for various water velocities, conductivity and species of fish encountered.

CATALOG DIGESTS

49 ELECTRONICS, ORDNANCE AND CAMERAS

Hycon Manufacturing Company—Has put out a booklet showing their products for consumer, industry and the armed forces, and their research division searching for the development of better methods and new areas of profitable enterprise. Rockets, aerial reconnaissance devices, cameras, electronics test instruments and guided missile ground support equipment are among their array of products.

50 ENGINEERING TEXTBOOKS AND REFERENCES

The Ronald Press Company—Described in a special brochure is a selected list of current technical books of special interest to the engineer. These authoritative and up-to-date references and textbooks cover many important aspects of structural analysis, design, engineering economy and management.

51 FIBRE FORMS

Sonoco Products Company—Sonotube Fibre Forms, as explained in this recent brochure, were developed to provide an economical method of forming round columns of concrete. The pamphlet shows photographs of actual job applications of the forms.

Return the coupon today!

52 FINISHING MACHINES

The Flexible Road Joint Machine Co.—A complete description of the new Flex-Plane Self Widening Finishing Machine is given. This new booklet, just off the press, completely describes the action of the machine and has many illustrations showing this machine in use on major turnpikes.

53 FLOOR ARMOR

Irving Subway Grating Co., Inc.—Just published is a new catalog on Gridsteel Floor Armor. Gridsteel is made of steel bars on edge, bent and joined together in a continuous hexagonal mesh pattern. Floors armored with Gridsteel last indefinitely. Gridsteel prevents ruts or potholes from forming, gives an even tractional floor surface at all times. Catalog illustrates uses, advantages, and shows how quickly and simply Gridsteel is installed.

54 FLOOR GRATINGS

Borden Metal Products Co.—A catalog containing technical information on how to select, design, purchase and install floor gratings, safety steps, floor armor is offered. Safeload tables, step-by-step procedure for ordering, planning and checking is included.

55 FOUNDATION PILES AND CAISSONS

Franki Foundation Company—Has a profusely illustrated, 12 page brochure that describes in detail the Franki method of installing Displacement Caissons and Pressure Injected Footings. Energy per blow of 150,000 foot pounds is expended in forging the concrete bases. The colorful bulletin also describes various types of pile foundations installed by Franki, design data and test data on representative projects.

56 FOUNDATIONS

Drilled-In Caisson Corporation—Literature describes foundation columns anchored in rock sockets; heavy column loads carried on single caissons; penetration through any type of soil to rock at any depth; economy in time and labor; foundation bonded in rock; and description, design, specifications, technical data.

To the Executive Secretary of ASCE
33 West 39th Street, New York 18, N.Y.

☐ I wish to take part in the work of the Pipeline Committee.

☐ I volunteer as a worker on the following sub-committee:

....

☐ I volunteer as a speaker on the following subject:

....

☐ I suggest the following as a speaker and subject:

....

☐ Attached are my suggestions for future programs, speakers, other activities, possible new members, or informative data for your files.

☐ I am in favor of a new Pipeline Division.

☐ If a new Pipeline Division is formed, please enroll me.

☐ I am now enrolled in the.................. Division.

Signed:............................Grade:........

Address:..

....

Company:..

Title:..

Nature of position:..

CATALOG DIGESTS

57 FOUNDATIONS

Spencer, White & Prentis, Inc.—Has literature on the construction of difficult and unusual foundations, description of concrete-filled steel tubes driven to rock, including technical data, performance and installation, description of Pretest Underpinning and the application of the Pretest Method.

58 GAS STORAGE

Chicago Bridge & Iron Company—An eight-page technical article, "Greater Gas Storage in Hortonspheres," describes the recent progress in the use of new materials and their effect on the design of Hortonspheres for the storage of gas under pressure. The article contains graphs and photographs illustrating significant changes.

59 GEARS

The Earle Gear and Machinery Company—A twenty-page catalog describes in general, the kinds and sizes of gears manufactured by this company. Its contents deal with Spur Gears, Bevel Gears, Helical Gears, Worm Gears, Racks, Non-Metallic Gears, Sheaves, Sprockets, Special Machinery of which Gears form a part, and Special Gear information. Illustrated with photographs, it also shows actual Earle installations.

60 GRATING AND TREADS

Klemp Metal Grating Corporation—A 16-page Data and Specification Manual covering all types of grating, open steel floor armor, stair treads, vessel liners, bridge decking and drain gates has just been published. Including all information and data vital to the engineer, the book is a "tool" for industries dealing in construction, oil, traffic, building, chemicals, food processing, railroads, transportation, shipping, safety, factories, heavy equipment, petroleum and maintenance.

61 GRATING FLOORING AND TREADS

Irving Subway Grating Co., Inc.—General Grating Catalog F400 contains illustrations, descriptions and complete engineering data on grating flooring, treads and floor armoring (riveted, press-locked, welded types). Irving Grating is safe, durable, fireproof, ventilating, clean and economical for industrial and power plants and refinery walkways, stairways, driveways, trucking aisles.

62 GRAVITY FILTERS

The Permutit Company—Bulletin 2539B describes in its 24 pages the complete line of gravity filters and filter accessories: manually operated, semi-automatic, including operating tables, rate of flow controllers and gauges. Specifications, operating instructions, outline dimensions and typical installation photographs have been included in this new edition.

63 GUNITE

Pressure Concrete Company—Has a 48-page illustrated, free booklet on Gunite in all of its phases. The booklet contains specifications, job stories and illustrations showing Gunite repair of reservoirs, dams, filter plants, sewage disposal plants, stadiums, bridges, stacks and bunkers. The booklet also contains photographs on new prestressed tank construction and other data. A new leaflet just published illustrates pressure grouting to dams.

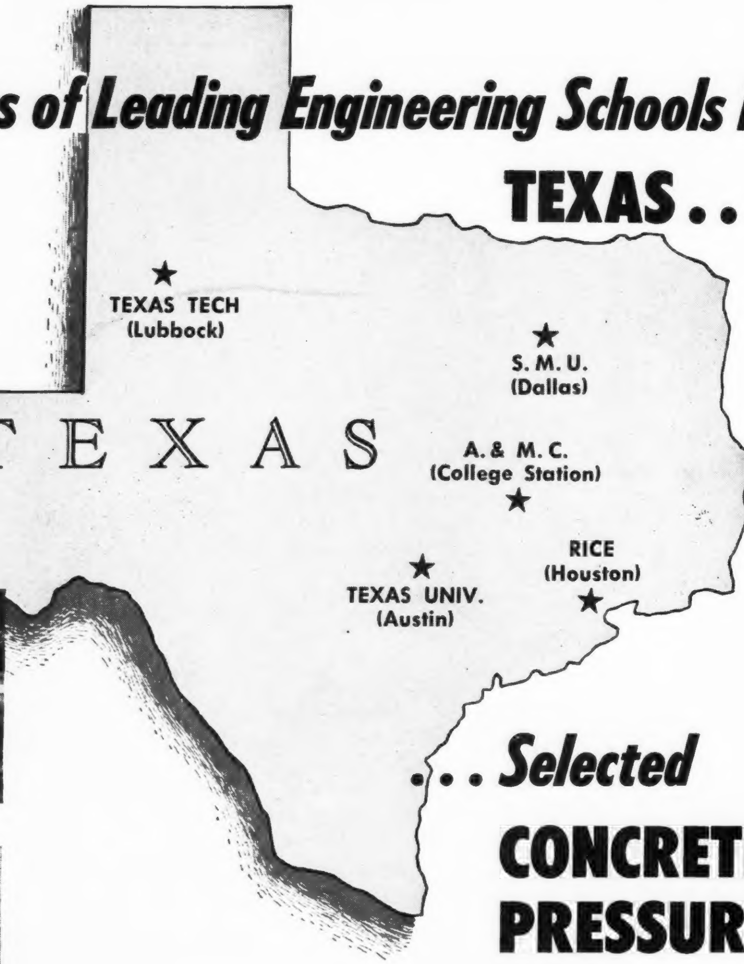
64 HAND LEVER DRILLS

Acker Drill Co., Inc.—Acker Bulletin 21 describes both Acker LD and LLD hand lever feed core drills for foundation test drilling, highway test cores, moderate depth mineral prospecting.

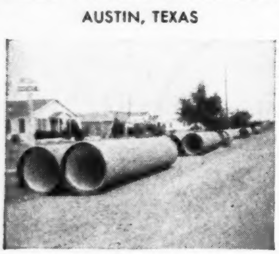
65 HANDLING AND STORAGE OF

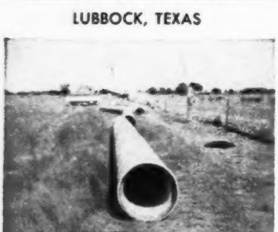
Sauerman Bros., Inc.—New brochure, MMM No. 2, shows how Sauerman engineers develop storage systems to meet the needs of the bulk chemicals industry, and work with consulting engineers and plant designers to fit scraper storage into the building plans. A variety of installations are shown as well as many layout drawings and photos.

The Homes of Leading Engineering Schools in TEXAS . . .




AUSTIN, TEXAS


LUBBOCK, TEXAS


COLLEGE STATION, TEXAS

. . . Selected CONCRETE PRESSURE PIPE

The five cities shown on the above map where the leading Engineering Schools of TEXAS are located have large CONCRETE PRESSURE PIPE installations in their water systems. In other words, the Engineers of today selected for the Engineers of tomorrow CONCRETE PRESSURE PIPE thru which they receive pure clear sparkling drinking water. Such popularity of Concrete Pressure Pipe in Texas must be deserved!

Member companies manufacture Concrete pressure pipe in accordance with nationally recognized specifications

Concrete PRESSURE Pipe

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION
228 North LaSalle Street
Chicago 1, Illinois

WATER FOR GENERATIONS TO COME

66 HIGH HEAT TREAT STEEL

Lockheed Aircraft Corporation in Burkbank—A report on "High Heat Treat Steel," taken from one of Lockheed's monthly engineering and manufacturing forums. The report summarizes some of Lockheed's experience with high heat treat steel and is one of the brochures offered career-conscious engineers by Lockheed's recruiting department.

67 HOPPERS

Gar-Bro Manufacturing Company—A four page colored booklet describes both concrete receiving hoppers and floor hoppers. The latter are designed to be intermediary between mixer and concrete carts to prevent delay of crew or truck mixers, and have many other uses. The receiving hoppers are made with either single and double gates types, in both the vertical front and center discharge types. They feature lifting eyes at corners for tie back when used as tower hoppers, occasional use as a concrete bucket, and for lifting from floor to floor.

68 HOT OIL HEATER

Wm. Bros Boiler & Mfg. Co.—A new 4-page folder illustrates and explains the features of the new Bros Hot Oil Heater which includes: rapid heat transfer, coil furnace efficiency, "cold oil" seal feature, completely automatic operation and electric driven smoothness. It tells how the heaters are applicable to many industries where heating temperatures up to 600° F. are required and operation at atmospheric pressures are desirable. Reasons for lower operating and maintenance costs of the heaters are also presented.

69 HYDRAULIC CRANE

Austin-Western Co.—An 8-page catalog, AD-2206RI, pictures and describes the new Austin-Western hydraulic crane. This tractor-mounted crane, with its pickup, carrying, and placement capabilities, combines the best features of crawler, truck, and erection cranes with those of industrial shop cranes. All movements are actuated by fast, smooth, hydraulic control.

70 HYDRAULIC DATA BOOK

Leupold & Stevens Instruments, Inc.—Interpretive data on water measurement and control is at your fingertips in this 144-page revised edition, in three parts: Float Wells and Instrument Shelters; Errors in Float Operated Devices; Hydraulic Tables; plus pages for notes and memorandums. Indispensable for the engineer with its wealth of information, tables, charts and illustrations. The price is $1.00.

N. B. There is a charge for this book. Make checks payable to Leupold & Stevens Instruments, Inc.

71 HYDRAULIC TURBINES

The James Leffel & Co.—Interesting and varied literature and bulletins describing complete line of hydraulic turbines—Francis, Impulse, and Propeller designs.

72 INCINERATOR STOKERS

Flynn and Emrich Company—Bulletin No. 1702 fully describes proved design of automatic stokers for municipal and industrial incinerators. The bulletin clearly shows the design and operation of this simple, rugged and dependable incinerator stoker that has proved itself in the field. The bulletin also includes an up-to-date history of incineration.

73 INCREASING CRANE CAPACITY

Sauerman Bros., Inc.—Field Report No. 228 tells how to extend the reach of your crane and in many cases double its capacity with a Crescent scraper. A layout drawing illustrates the Sauerman method, and three pages of on-the-job photos support this promise of increased range and greater payloads. The report describes the advantages of scraper operation on certain jobs and offers an engineering service that will determine the largest size Crescent your machine can handle. Just give make, model number and boom length of your crane.

74 INDUSTRIAL AND MUNICIPAL WATER

Ranney Method Water Supplies, Inc.—Have available a 20-page illustrated booklet describing Ranney horizontal water collectors and their advantages in the development of large supplies of clear non-turbid water for municipalities and industries. It is called "Industrial and Municipal Water".

75 INDUSTRIAL POWER EQUIPMENT

Allis-Chalmers Manufacturing Company—A 12-page two-color catalog tells how modern industrial power equipment fits into the farm conservation scene to help in land clearing and land reclamation, earthmoving for irrigation and drainage, terrace and diversion channel construction, pond and reservoir building and other jobs requiring power and versatility of crawler tractors, motor graders or scrapers. On-the-job photos of the equipment graphically illustrate the equipment in action.

CATALOG DIGESTS

76 INDUSTRIAL PRODUCTS CATALOG

Johns-Manville—Has issued a new edition of its 40-page catalog which offers essential data on the following groups of products: Insulations, Refractory Products, Asbestos Cement Pipe, Packings, Gaskets, Electrical Products, Frictional Materials, Roofing, Siding, Flooring, Partitions, and Ceilings. Photographs, diagrams, and text have been revised and brought up-to-date so that engineers and plant executives will have the latest information in a compact catalog that is easy to use.

77 JETTING PUMPS

Griffin Wellpoint—A booklet illustrates jetting pumps for pile and caisson jetting, oil pipe line testing, water supply, fire protection. The illustrations show unusual set-ups for high-pressure jetting, including parallel and series pumping arrangements. The units included range from 200 to 1400 g.p.m. with pressures from 100 to 700 lbs per sq in.

78 JOINT SEALER

Sika Chemical Corporation—A brochure describes flexible non-meltable Igas joint sealer for water reservoirs, concrete tanks and deep basements. Specifications and architectural details are included on separate sheets.

79 JOISTS-T-CHORD LONGSPAN

Haven-Busch Company—A well illustrated 35-page booklet explaining types, uses and advantages. Contains charts and specifications, load tables, accessories and applications, also check list for requesting estimators.

80 KOMPACTOR

Buffalo-Springfield Roller Company—An eight page colored booklet explains the K-45 Kompactor. It is self-propelled, highly maneuverable, works on steep embankments, and close to abutments and culverts. The advantages of its reductions in time and cost estimates are fully outlined. Specifications accompany the data.

81 LAYING CONCRETE PRESSURE PIPE

Price Brothers Company—Offers the new, revised "Laying Manual"—a pocket-size book of instructions for laying concrete pressure pipe via the backhoe method. Contains up-to-date instructions (with photos and drawings) of proper trenching, checking grade, handling pipe, and completing the flexible watertight rubber and steel joint. Also shows a check list of equipment and supplies needed for the job. Clear and concise, this revised manual is valuable for engineer and contractor.

82 LAYNE BULLETIN

Layne & Bowler, Inc.—Has just released a new 20-page bulletin, NA-55, featuring a partial list of national and international firms served by the Layne organization, world's largest water developers.

83 LIFT TRUCK

Wm. Bros Boiler & Mfg. Co.—A folder on the Bros Lectro-Lift material handling truck body shows how it operates and why it is especially adaptable to handling concrete blocks and similar materials.

84 LIFT-TRUCK SCALE

Martin-Decker Corporation—This carefully engineered device fits any upright hydraulic-cinder type lift truck, is easy to install, accurate and reasonably priced. The scale enables the driver to know the weight picked up, thus assuring him a full load with safety. It permits floor weight distribution, simplifies weight inventories, and prevents highway truck overload fines.

CATALOG DIGESTS

85 LONG-SPAN Q-DECK

H. H. Robertson Company—Full information ou exceptionally Long-Span Deck. Describing ease of handling and erecting for lengths up to 32 feet. Designed especially for schools, supermarkets and other structures where long, unbroken spans and structural steel savings are beneficial. Contains structural details, load tables and specifications.

86 LOW BED TRAILERS

Birmingham Manufacturing Company, Inc.—Offers a brochure showing specifications and photographs of Machinery trailers, from 15 to 265 tons. This company also offers special engineering service designing trailers for unusual loads. They feature units with very low center of gravity, off the road equipment and oil field specialties.

87 MAPPING PRODUCTS

Fairchild Aerial Surveys, Inc.—A quick reference guide to Fairchild mapping products shows the materials and methods for producing different types of maps. Included are oblique and vertical photos, photo index and line index, controlled mosaic or photomap, topographic contour map, magnetic contour map, and radioactivity contour maps and strip chart.

DID YOU MAKE YOUR CHECKS PAYABLE TO THE PROPER COMPANIES? ARE THE AMOUNTS CORRECT?

88 MASONRY CEMENT

Lone Star Cement Corporation—A 16-page, illustrated booklet outlines the advantages of Lone Star masonry cement in simplifying the problem of obtaining uniformly high-quality mortar, as well as the economy of one rigidly standardized, ready-to-use cementing material instead of two with no lime or Portland cement to add, and no soaking or slaking. It provides timely information on soundness, low absorption, high water repellency and other factors contributing to durable, weather-resistant performance. It contains easily-read graphs showing effect of mix proportions on water retention, strength and absorption, effect of mixing time on water retention, along with convenient reference tables for estimating quantities.

89 MECHANICAL JOINT PIPE

American Cast Iron Pipe Company—A book entitled "American Double-X Mechanical Joint Pipe" has been published by the manufacturers of Mono-Cast Pipe in diameter 2" through 48", inclusive. The book has 44 pages and is illustrated. It contains specifications and tables of standard dimensions, thicknesses and weights.

90 METERS, FEEDERS, AND CONTROLS

B-I-F Industries, Inc.—B-I-F 5 is a 12-page, 2-color booklet which explains a varied line of equipment for metering, for chemical feeding and proportioning, and for controlling processes and operations. Builders-Providence, Inc. manufactures a complete line of instruments for metering and controlling the flow, liquid level, temperature, pressure, weight, and the latest chlorine gas feeder. Proportioneers offers many standardized machines and systems for automatic treating, feeding, diluting, blending, proportioning, and sampling. Omega Machine Co. presents a diversified line of volumetric and gravimetric feeders for dry materials and for feeding liquids by gravity and designed for continuous, accurate, and economical operation.

91 METRIC WALL CHART

Mayo Tunnel and Mine Equipment—Simplified metric conversions, originally designed for the Mayo company office is now available. Chart includes: Feet to Meters; Inches to Meters; Decimals of a Foot; Meters to Feet plus other useful conversion factors. Illustrated are Mayo steel forms, tunnel shields, grouters and other Mayo equipment for the mining industry.

CATALOG DIGESTS

92 MINE, SHAFT AND INCLINE HOISTS

Superior-Lidgerwood-Mundy Corporation—The 16-page bulletin M515 describes and illustrates a full range of steam, electric, gasoline and diesel powered hoisting, machinery which is "engineered and designed to suit," yet consists of standard parts. Also described are hoists for special purposes. included are 36 illustrations of important installations; data required for estimating on mine, shaft and incline hoists; general information on mine hoists and hoists for shafts and slopes.

93 MOTOR GRADER

Galion Iron Works & Manufacturing Company—Has released a new highly-illustrated sixteen-page catalog on their model 503 economy motor grader. The numerous construction and operating features of this unusually versatile machine are completely described. The many big grader type attachments which make this machine a complete maintenance department in itself are also fully described. This optional equipment includes hydraulic shiftable moldboard, front-end scarifier, leaning front wheels, bulldozer and many other features.

94 MOTOR SCRAPERS

Allis-Chalmers Manufacturing Company—The TS-200 motor scrapers and TR-200 motor wagon, rubber-tired earthmoving units, are described in the two-color catalog in which components of the two units are also featured. Numerous action photos are used to tell a graphic story of job application by the two units. The motor scraper has a 10-cu yd struck and 13-cu yd heaped capacity; the motor wagon has 11-cu yd struck and 15-cu yd heaped, or 18 tons capacity.

95 PANEL FORMS

Superior Concrete Accessories, Inc.—A profusely illustrated bulletin explains the form panel without a metal or wooden frame. The combination clamp is the only basic working part in this new panel form.

96 PENCIL SAMPLE KIT

American Pencil Company—The new Venus Blueprint Pencil Sample Kit is now available. See for yourself how new Venus Blueprint Pencils give you more brilliant, clear, non-smear markings on all blue or white prints and coarse papers. Specially formulated lead is the reason. Sharpens to a needle point, never powders or smudges; markings are opaque and insoluble, resist oil and grease. Electronically controlled color accuracy. Kit includes two new Venus Blueprint Pencils plus a Venus Drawing Pencil.

97 PENTA

Monsanto Chemical Corporation—Has distributed a folder on Penta, a chemical compound, used among all major industries which depend on long service from wood. It has met the needs for maximum wood protection in public utilities, railroads, public buildings, and industrial construction. Penta treated wood is a clean preservative, easy to work on and requiring minimum maintenance and replacement. It resists decay, insects, termites, and water leaching. In addition. Penta treated wood can be painted, if specified.

98 PHOTOELASTIC POLARISCOPE

Polarizing Instrument Co., Inc.—A new catalog describing new apparatus is now available. Four new Polariscopes and two Straining Frames are featured.

99 PILES

Raymond Concrete Pile Company—Standard and step-tapered piles are described in Catalog S-55 which also includes information on the scope of Raymond's activities covering every recognized type of pile foundation. Domestic operations include harbor and waterfront construction, and cement-mortar lining of pipelines in place. Raymond's services abroad also include all types of general construction.

CATALOG DIGESTS

100 PILES

The Union Metal Mfg. Co.—Test load data, engineering tables and descriptive information are contained in Catalog No. 81 on Monotube piles. It also includes numerous photos showing a wide range of job applications throughout the country. Advantages listed: light weight, easy handling, speedy driving, economical field extensibility, visual inspection after driving, high load-carrying capacity with consequent economy per ton of load carried.

101 PIPE, COUPLINGS

Naylor Pipe Company—As a help to engineers in the construction field, Bulletin No. 507 is available. It provides concise data on large diameter light-weight pipe, fittings and couplings, and covers specifications on pipe from 4 inches to 30 inches in diameter, standard fittings and welding flanges. Also included in the bulletin are details on the Naylor one-piece Wedge-Lock coupling.

102 PLANT DESCRIBED

Flint Steel Corporation—Offers three, 12-page, two-color brochures describing the over-all sales, engineering, detailing, estimating and fabrication facilities of the Tulsa and Memphis Plants. The three specialized divisions of the company are described separately, one in each book. They are galvanized towers and substations, structural and reinforcing, and plate and tank divisions.

103 POCKET TRANSIT

Wm. Ainsworth & Sons, Inc.—A booklet describing and outlining the use of the Brunton pocket transit and accessories is available. The booklet shows how horizontal and vertical angles can be determined to approximately one degree by an instrument weighing only 8½ ounces.

104 POOL CONSTRUCTION & EQUIPMENT

National Pool Equipment Co.—A discussion of several pool shapes and sizes is the subject of this colorful 16-page catalog. Filtration, chlorination, structural design are only a few of the topics considered.

105 POOL CONSTRUCTION & EQUIPMENT

National Pool Equipment Co.—A promotion piece is now available on the newly developed pre-cast, packaged pools complete with filtration system and all pool fittings. Construction costs are cut almost in half with these pools.

106 POOL EQUIPMENT

National Pool Equipment Co.—Has a new 26-page catalog fully illustrating the most complete, highest quality pool supplies and equipment. It is also full of charts for the prospective pool owner, architect or engineer.

107 PORTABLE ASPHALT PLANTS

Madsen Iron Works, Inc.—Has published several booklets on its portable asphalt plants. Model 481 is designed for the ultimate in portability. The "Little Monster" was built to meet the demand for a small, high capacity asphalt plant unit. In addition, other bulletins give information on dust collector units, and twin-shaft pug mill mixers.

108 PORTABLE BATCHING PLANTS

The Heltzel Steel Form & Iron Co.—A completely new brochure giving full description together with necessary illustrative matter on the Heltzel Type 100 Batching Plant that has been so popular with paving contractors. Straight aggregate and combination plants are covered. Cement recirculating systems, batchers, including water, materials handling equipment, and batching accessories are all discussed.

CATALOG DIGESTS

109 PORTABLE GASOLINE RAMMER

Barco Manufacturing Company—Offers an eight-page catalog describing the Barco Portable Gasoline Rammer for soil compaction. This tool is the only successful mechanical means of obtaining specified soil compaction in restricted areas such as in trenches and near walls and bridge abutments. It is easy to operate, safe, and will compact 20 to 30 cubic yards of fill per hour where high degree compaction is specified. Barco also offers a bulletin "Cost Data for Soil Compaction in Restricted Areas with the Barco Rammer" of interest to all earthmoving contractors.

110 PORTABLE POWERED RIGS

Acker Drill Co., Inc.—Acker bulletin 28 describes both Acker light duty RGT and heavy duty RG portable powered soil sampling rigs. Acker SK drill heads are also described. This unit can be added to either the RGT or RG units for rock coring.

111 POWER RATING CHART

Waukesha Motor Company—In Bulletin 1079-B complete tabulations are given for dynamometer horsepowers with complete speeds and loads for all types and sizes of diesel, gasoline and natural gas engines. Ratings are in accordance with standards of the Internal Combustion Engine Institute.

112 PRECAST CONCRETE WALL PANELS

Portland Cement Association—A 16-page illustrated booklet discusses various types of precast concrete panels and shows their use in buildings where walls are attached to the structural frame. Line drawings illustrate details for different panel types including solid sections, sandwich, thin-wall and others. Inserts, joints and methods of attachment are also shown.
(Sent in U.S. and Canada only.)

113 PRE-CAST REINFORCED CONCRETE

American-Marietta Company—A brochure on Inner Circles Tunneliner Pipe of pre-cast reinforced concrete. Illustrations show how elliptical sections pass through conduit already laid without disturbing the surface above or disrupting traffic. Graphs give hydraulic properties and discharge curves. Specifications are listed for I.D. of round pipe equivalents from 33" to 96" and many installation photos are included.

114 PRECIPITATOR

The Permutit Company—Bulletin No. 2204C is a well-illustrated and documented 20-page pamphlet describing the many applications, principles of operation, design features, advantages, recommendations, flow diagrams and specifications of Permutit's Precipitator. It supersedes the earlier edition, issued in December 1953. The Precipitator offers, through its three basic designs, an efficient means of removing impurities from a liquid by precipitation, absorption, settling and filtration. Chief uses are in water softening, the reduction of alkalinity and the removal of turbidity, color, taste, odor, silica and fluoride.

115 PRECISION INSTRUMENTS

C.L. Berger & Sons, Inc.—Complete specifications on the Berger "N" line of moderate priced builders' instruments are included in an illustrated brochure now available. Companion line to the company's engineering, mining and astronomical instruments, the "N" line consist of a convertible transit-level, a 12-in. heavy-duty dumpy level, a service transit level (farm level), a hand level and optical tilting level.

116 PRECISION INSTRUMENTS

C. L. Berger & Sons, Inc.—An informative, 4-page brochure, combining a catalog and calculating chart has been prepared. Pictured in four colors on the cover is the Berger Type R transit, one of the many instruments produced by the 84 year-old firm. On the center spread are photographs and code names for 12 types of Berger instruments, from an 18-in. dumpy level to a plane table alidade.

SOCIETY JEWELRY
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Executive Secretary
American Society of Civil Engineers
33 West 39th Street
New York 18, N. Y.

Enclosed is my check for $_______ for the purchase of:

For Members (M., A.M., and Aff.)

☐ Badge (pin)	$5.50
☐ Badge (watch charm)	5.50
☐ Lapel Button	3.30
☐ Tie Clasp	4.95
☐ Tie Chain	9.35

For Junior Members

☐ Badge (pin)	$2.20
☐ Badge (watch charm)	2.20
☐ Lapel Button	1.38

(Prices listed include 10% Federal Excise Tax. This tax is not payable on export orders.)

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Address ....

City ....
(where emblem is to be sent)

CATALOG DIGESTS

117 PRECISION INSTRUMENTS

C.L. Berger & Sons, Inc.—"Solar Ephemeris and Polaris Tables," 1955 Edition, 96 pages, contains complete instructions for determining azimuths from the sun and the altitude of Polaris, prepared by Herman J. Shea, Associate Professor of Surveying, Massachusetts Institute of Technology. Directions for making astronomical observations and computing results by direct solar observation and time from same observation: meridian by solar attachment; meridian by Polaris at elongation; azimuth by Polaris at any hour angle; latitude by sun at noon, and latitude by Polaris are included, as well as all requisite tables. Price is $.50 per copy.

N. B. There is a charge for this book. Make checks payable to C. L. Berger & Sons, Inc.

118 PRESSURE FILTERS

The Permutit Company—Bulletin 2225B describes Permutit's extensive line of pressure filters and their accessories. These filters are being used to remove suspended solids such as dirt, turbidity, iron, oil and color from water supplies. Specifications, operating characteristics, outline dimensions and typical installation photographs have been included in this revised edition.

119 PRESTRESSED BRIDGE MEMBERS

American-Marietta Company—This brochure shows with photos and blueprints how Amdek Prestressed, Pretensioned Concrete Bridge Members are constructed. Weights and depths of beams are given, as well as the results of load tests. Illustrations show bridges under construction and completed Amdek installations.

Return coupon on page 168

120 PRICE LIST

Clipper Manufacturing Company—The current price list of this company includes specifications on Clipper Masonry Saws, Accessories, Concrete Saws, Abrasive, and Diamond and Break-Resistant "Polk-A-Dot" Blades. Colorful folders are available describing the powerful new Model C-360, 36 Horsepower Concrete Saw and the 25 and 14.6 Horsepower Concrete Saws. Clipper's Joint Sealing Machine, Model AC-40, is covered in detail in Form #6003. Also given are the 25 direct factory branches.

121 PROPANE FLOODLIGHTS

Wm. W. Lee and Son—Literature is now available on the new BL-64 flood-light, a self-contained unit, completely portable, which provides a light of 6000 c.p. and throws a beam approximately 150 × 75 feet. This Til-Lee propane floodlight can be instantly lighted with a match, is unaffected by weather, and will operate in temperatures down to 45 degrees below zero. The BL-64 will give 50 to 150 hours on a 20 pound tank of gas depending on the operating pressure.

122 PUMPS

Byron Jackson Company—Bulletin 51-6600 describes VHT, VMT, and VLT pumps designed for handling liquids, hot or cold, corrosive or non-corrosive, where the net positive suction head is limited, and where space is at a premium. The vertical construction of these pumps reduces floor space requirements. Twelve pages are devoted to explaining the three types of pumps, with photos of actual installations shown.

123 PUMPS

Johnston Pump Company—Three brochures are available. Bulletin 1015 describes oil and water lubricated vertical turbines, with semi-open or closed type impellers. They are furnished for use with any type of power. In Bulletin 1018, the low-cost "Little Beaver" pump which is available in a wide range of sizes, is described. These pumps are adaptable to every water supply use. Bulletin 1028 contains selection tables, dimensions, and material descriptions of gasoline dispensing pumps for use in service stations, fleet terminals, and aircraft refueling.

CATALOG DIGESTS

124 REINFORCED CONCRETE PIPE

American-Marietta Company—This pamphlet covers elliptical Lo-Hed Reinforced Concrete Pipe for culverts and sewers. Specifications are given for the complete range of sizes from the equivalents of round pipe 18" I.D. through 120" I.D. Illustrations show results of pressure tests and installations of Lo-Hed pipe being made on various types of jobs.

125 REPRODUCTION MATERIALS

Eastman Kodak Company—This brochure features the company's several reproduction papers and tells how they work. List prices and sizes of the Kodagraph materials and chemicals area included along with a reproduction materials selection chart to help in the selection of the material best suited to any reproduction job.

126 RESTORATION OF STONE STRUCTURES

Western Waterproofing Co., Inc. of Missouri—An 8-page booklet describes the building cleaning and tuckpointing services for maintenance and restoration of stone structures and explains the importance of each. Various methods of cleaning are compared in photographs of a building on which all methods have been employed side by side. Tuckpointing and restoration services that provide sound, leak-proof mortar joints are also described.

127 RIGHT ANGLE SPEED REDUCERS

Western Gear Corporation—Has put out a bulletin, No. 5503, of essential data and information on right angle speed reducers as an aide to engineers, designers, and users of power transmission equipment. The speed reducers described are designed and constructed in accordance with the latest approved engineering practice. They are quiet and efficient and insure a maximum of service with a minimum of attention. There is one for every application in every type of industry.

128 ROLL-O-MATIC TANDEM ROLLERS

Galion Iron Works and Manufacturing Company—Has issued a new catalog on an advanced type of tandem roller drive called Roll-o-Matic, which utilizes a torque converter. This new drive sets a new standard of effective driving power and accomplishes worthwhile reductions in fuel consumption, mechanical wear, and maintenance. In addition, the elimination of gear shifting and master clutch makes the tandem roller extremely easy to operate, and any selected roller speed is closely and automatically maintained.

129 ROTARY MASONRY DRILLS

Termite Drills, Inc.—Has published a brochure containing vital information concerning its rotary masonry drills. With special dust-removing worms, multiple insert design and special steels, these drills penetrate the hardest concrete, wire mesh and steel plate faster, quieter and with less pressure. The many varieties of Termite Drills, meeting the need for every masonry drilling need, are described in Bulletin TD-1.

130 SAFETY EQUIPMENT

E. D. Bullard Co.—Has prepared a Safety Equipment Catalog designed to give complete information on all Bullard Safety Products in a quick and efficient manner. On all pages clear photographs of the items being explained are shown along with easy-to-read technical data. Listed are addresses and phone numbers of Bullard Distributors who stock Bullard Safety Products for immediate shipment.

131 SCRAPER

Wooldridge Manufacturing Div.—Bulletin No. 1001-R1 contains information and pertinent specifications on the Terra Cobra Model TH-0142, self-propelled scraper.

132 SCREENING EQUIPMENT

Link-Belt Company—The complete Link-Belt line for efficient removal of solids from water, sewage and industrial waste is described in the 28-page book, No. 2587. Dimension and specification data for four types of coarse screens and three types of fine screens, plus tables to determine the proper size unit handling various capacities, are given.

133 SELF-PROPELLED ROLLER

Wm. Bros Boiler & Mfg. Co.—A 2-color brochure describes the Bros self-propelled pneumatic tire roller, the SP-54, first all-rear-wheel drive roller with every pair of wheels oscillating. It illustrates the outstanding Bros design features especially engineered for smooth, fast, and economical operation on mat surfacing, seal coating and compaction jobs in the standard lift range.

134 SELF-REDUCING PLANE TABLE ALIDADE

Kern Instruments Inc.—A new brochure gives exact details about the new self-reducing plane table alidade. This completely new instrument eliminates use of Slide Rule, Offset Scale and Dividers. Horizontal distances, measured directly with the reducing Telescope, are transferred with a parallel plotter. A new 27x, AR coated telescope embodies distance and height curves, fixed eyepiece and upright image. Actual working experience shows time in field cut by 50%.

CATALOG DIGESTS

135 SENSATER

Martin-Decker Corporation—Offers literature describing a new kind of hook scale which is accurate, inexpensive and works without friction. It is unaffected by temperature changes, of light weight, and installation is a simple one-man operation. The dial face has two concentric sets of increments for distant and for extremely accurate reading.

136 SEWAGE REGULATORS

Brown & Brown, Inc.—Bulletin 81 with supplements A and B describes sewage regulators designed to automatically control diverted sanitary flows from combined sewer systems, either by cutting off such flows entirely during storm periods, or by governing such diversions to a constant predetermined quantity regardless of storm conditions. Charts for the ready solution of diversion problems are included.

RETURN THE COUPON TODAY FOR IMMEDIATE RESULTS!

137 SLINGS AND FITTINGS

Leschen Wire Rope Division—Bulletin FS-51 devotes a complete coverage to slings and fittings with many illustrations, diagrams, charts, and accompanying data. For many applications wire rope is far more efficient in the form of slings designed for each specific use. This catalog provides a detailed description of the many types of Leschen Standard, Grommet and "Flat-Laced" Slings and Leschen Wire Rope Fittings.

138 SLUICE GATE

Rodney Hunt Machine Company—The first basic improvement in sluice gates in many years, the patented HY-Q Flush Bottom Closure sluice gate, is described in Catalog 75. The newly released booklet, with 12-pages of illustrations, clearly shows all details of construction, installation, and operation of the unique gate as used in water filtration plants, power plants, municipal and industrial plants, drydocks, and flood control. Diagrams and text explain the many practical advantages offered by the HY-Q gate for water flow control. Complete recommendations for selection of frames and other equipment for sluice gates, as well as detailed specifications, series numbers, and clearance dimensions are also given.

139 SOIL COMPACTION

Vibroflotation Foundation Company—"Soil Compaction by Vibroflotation"—a 12-page booklet telling where soil compaction by vibroflotation is applicable, how it is used to best advantage, the results achieved, and its outstanding features. Its use for industrial purposes, earth dams, airports and highways, deep foundations, excavations, and concrete dams is described. Graphs, illustrations, photographs, and a question and answer section explain the operational features of vibroflotation and its economical advantages.

140 SOILS & ENGINEERING MATERIALS TESTING EQUIPMENT

Soiltest Inc.—New 1955 catalog on "Apparatus for Engineering Tests of Soils, Asphalt, Concrete and Materials" contains a complete and comprehensive list of specialized equipment, together with descriptive literature for engineering testing apparatus. Operating procedures for the more complex methods of tests are given. The catalog lists apparatus needed to equip soils, concrete and bituminous laboratories.

141 SPEED REDUCERS

The Earle Gear and Machinery Company—A sixteen page illustrated catalog, describing Speed Reducers as applied to operating machinery, particularly bridge machinery, is available. Outlined are specifications, service factors, horsepower ratings and dimensions of the particular units illustrated. Gasoline Power Units are also dealt within a compact, easy-to-read form. Photographs are shown of actual installations with miniature blueprints included.

142 SPEEDWALK

Stephens-Adamson Manufacturing Company—Have published a booklet describing the moving sidewalk system which can be effectively used wherever large crowds must be moved quickly and safely, in an orderly flow. Designed with an eye to both human physiology and psychology, it will meet the need of mass transportation in terminals, airports, factories, sports arenas and shopping centers. Photographs and explanations of speedwalks already in use are included.

143 STANDARD PRODUCTS CATALOG

Link-Belt Company—A 340-page guide to one of the most complete standard lines of power transmission and conveying equipment is now available. This indexed book contains information for the engineer or layout man in selecting standard products for new installations or for replacements. It includes data on the line of chains for conveying and power transmission, ball and roller bearings, enclosed gear drives, clutches, gears, couplings.

144 STARTING A WATER WORKS

Cast Iron Pipe Research Association—A booklet titled "It Could Happen to You," written for the community that lacks a water supply system tells how to create favorable action by voters. Helpful to consulting engineers in getting plans off drawing boards and into actual construction. Available without charge in reasonable quantities to interested groups, civic and service organizations.

CATALOG DIGESTS

145 STEEL FABRICATORS

The Ingalls Iron Works Company—"Tailoring with Steel", a 32-page graphic presentation of structures fabricated and in many cases erected by the company. Included in the booklet are photographs of hospitals, office building, banks, commercial buildings, bridges, H-poles, hangars and hangar doors, power plants, industrial buildings, apartment buildings, institutions, warehouses, gymnasiums, grandstands, tanks, and fabricated plate work. The company's five fabricating plants are also pictured in the booklet.

146 STEEL FOR HIGHWAYS

Bethlehem Steel Company—This newly published 36-page illustrated booklet, "Steel for Highways," describes the broad range of Bethlehem steel products used in the construction of a modern highway. These include reinforcing bars, bar mats, dowel units, structural steel, wire rope, drill steel, pipe, guard rail and posts, fence and fence posts, sheet pilling and H-piling, culvert sheets, rock anchor bolts, etc.

147 STEEL RIGID FRAMES MANUAL

Martin P. Korn—Part one presents the fundamentals of analysis and design, including selection of type of frame, derivation of basic equations, and tables of design for single span frames of from 50 to 150 ft. Part two of the volume is a collection of actual designs of a number of structures: an auditorium, bridges, and others. Martin P. Korn is the author. (J. W. Edwards, Inc., Ann Arbor, Mich., 1953. 170 pp., $4.50.)

N. B. There is a charge for this book. Make checks payable to J. W. Edwards, Inc.

148 STRUCTURAL ARC WELDING

The Lincoln Electric Company—A continuing series of studies—how arc welding is used in modern structures is issued periodically. Case histories of welded bridges, buildings and miscellaneous structures: drawings, details and calculations for typical structures are included. Current series is a study of school buildings.

149 SURVEYING ALTIMETERS

American Paulin System—Micro and Terra Altimeters, and the Micro Surveying Barograph are illustrated, and their specifications given in this new brochure. The necessary accessories are listed as well.

150 SURVEYING INSTRUMENTS

C.L. Berger & Sons, Inc.—A 16-page condensed catalog, "Accuracy in Action," illustrates the engineering and surveying instruments manufactured by the company. General characteristics, optical systems and accessories for the Berger line of engineers' transits, levels, mining transits, theodolites, collimators and alidades are fully described with essential specifications for each. A section devoted to builders' and contractors' instruments is also included.

151 SURVEYING INSTRUMENTS

Fennel Instrument Corporation of America—Offers a folder on their line of precision instruments. Photographs, detailed descriptions of the models. Prices are included.

152 SURVEYING INSTRUMENTS

Kern Instruments, Inc.—A 32-page brochure offers a brief description of the most important instruments manufactured by world famed Kern & Co., Ltd., of Aarau, Switzerland. Fully illustrated, it acts as an index to the detailed literature available on each instrument. Included in the brochure are theodolites, levels, self-reducing tacheometers, alidades, pentagonal prisms and many other exceptionally fine instruments.

153 SURVEYING INSTRUMENTS

David White Company—Has issued a 32-page bulletin, No. 1054, covering their complete range of products, with price list included. A number of new items such as the European wide frame tripod, and wind-free plummets are featured, in addition to many varieties of surveying instruments for all purposes, engineers' supplies and cameras.

154 SURVEY MARKERS

Copperweld Steel Company—This four-page leaflet introduces non-rusting survey markers which will locate survey points permanently. Each marker consists of a steel core to which a thick copper covering is molten-welded. A new adapter available for the Copperweld Bronze-Head Marker provides an extra-large surface for stamping identification. The leaflet provides specifications and explanatory photographs.

There are 192 Digest items on pages numbered 168 to 194. Read all items for the literature of interest to you.

155 TAMPERS

Wm. Bros Boiler & Mfg. Co.—Brochure RE-140 covers tampers in medium and giant weights. Single, double and triple drum models are listed. Standard Sheepfoot Tampers and Standard Diamondfoot Tampers with relief shank are shown, also the Tamprite Feet with replaceable Tamprite Tips.

156 TANDEM ROLLER

Buffalo-Springfield Roller Company—The KX-3 Axle Tandem giving superior compaction for macadam, subgrades, and hot and cold bituminous is described in Bulletin S-6253. It will give up to 50% smoother surfaces, and features a Walking Beam Compaction Control.

157 TAUTLINE CABLEWAYS

Sauerman Bros., Inc.—This new 3-color catalog illustrates cableway applications that will be of interest to civil and consulting engineers, public utilities and industrial concerns. Sixteen pages of photographs, sketches, and text describe types, spans, working loads and other details of tautline cableways.

158 TECHNICAL DATA CATALOG

Lefax—Announces a newly revised catalog of Lefax Pocket Size Technical Data Books selling at $1.25 each. These handy books cover every field of engineering and are of constant use to engineers, technical men, construction workers, surveyors, shop men, teachers and students. Books contain about 140 loose leaf pages of up-to-date material; concise, comprehensive, authoritative. Partial listing includes: Surveying, Surveying Tables, Highway Engineering, General Math, Trig-Log Tables, Architecture, Building Construction, Reinforced Concrete, Piping Data, etc.

N. B. There is a charge for this book. Make checks payable to Lefax.

159 TENSION INDICATORS

Martin-Decker Corporation—Cable Tension Indicators can tell the amount of pull or strain on any cable, thus giving vital information for stringing and equalizing lines on suspension bridges and elevators. It can tell if lines are adequate to safely support the weights assigned to them, or conversely, tell the engineer if he is going to needless expense by using too many lines or lines that are far too heavy.

160 TERRAZZO

Trinity White Portland Cement—An eight-page colored booklet describes the advantages and specifications of Terrazzo Floors, wainscots and partitions. Terrazzos of colored stone set in Trinity White Portland Cement are noted for their economy, comfort, and wide range of color and design.

161 THEODOLITE

Geo-Optic Company, Inc.—Has a leaflet describing the optical universal theodolite Askania TKT Transit with terrestric telescope (erecting eyepiece). The Askania TKT Transit enables surveyors to cope with any possible problem of triangulation and to obtain results of the highest accuracy. All readings are done from one position—an important time factor. Other advantages and data are included.

162 TIDE GATES

Brown & Brown, Inc.—Bulletins 69 through 73, 75 and 76 describe various types of tidal gates, both circular and rectangular, and give authentic information regarding head losses.

163 TRACING PAPER

Clearprint Paper Company—Has drawing and tracing paper with "disappearing" grid lines now available in rolls. This time-saving "fade-out" paper is printed with light-blue cross section rulings which completely disappear on direct print reproductions and blue prints. Fade-out grid paper in rolls has proved to be ideal for applications such as wiring and plumbing diagrams; structural and architectural drawings; plant layouts, tool and parts designs, and surveyors' plottings. Clear-print's fade-out paper can be used for drawings of any required size. Catalog F-2 includes sample sheets, sizes and prices.

164 TRACK-TYPE TRACTOR

Caterpillar Tractor Co.,—has recently announced the new Caterpillar D9, considered the world's largest and most powerful tractor. Over 17 feet long, 9 feet wide, and 8 feet high, it is equipped with a completely new 286-hp. engine. In addition, it is the first track-type tractor with a turbocharger giving more working power and greater performance. Two types of drives are available, the six-speed (forward and reverse) transmission or a torque converter with three forward speeds and two reverse. Further information is included in Form 31555.

165 TRAFFIC MODEL

Rolatape, Inc.—A sheet with price list explains the Traffic Model which measures and records feet and inches as you walk, giving an accurate total at all times. One man can do the job of two or three in much less time for all traffic accident investigations. Braking distance, skid marks, and position of vehicles are among the many measurements which can be accurately and easily taken. Model 200 comes with its own luggage type carrying case.

166 TRANSIT

Wild Heerbrugg—A new piece of literature describes the reading principle of the new twenty second T-1 Repeating Transit. Model T-1 is now available as an alternative to the standard model (reading direct to one minute interpolations to six seconds) and gives direct reading to twenty seconds on both circles with easy interpolations to ten seconds.

167 TRANSITS

W. & L. E. Gurley—The complete line of surveying, and engineering instruments, including transits, levels, alidades are described in the newly-revised edition of Catalog 50. The bulletin includes a cross-sectional drawing of the Gurley Precise Transit. Transits described include the Hell Gate Precise Transit; Standard Precise Transit; the Gurley Telescopic Solar Transit; the Standard Precise Mining Transit; and the Optoplane Precise Transit for industrial use.

168 TRUE PIPING ECONOMY

A. M. Byers Company—Offers a digest of the important uses for wrought iron pipe in different types of industrial and municipal services. A yardstick for measuring basic cost factors in the installation of piping systems is contained in this eight-page, illustrated booklet.

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169 TUNNELS

Spencer, White & Prentis, Inc.—"Famous Subways and Tunnels of the World," by Edward and Muriel White. Recounts the fascinating history of subways and tunnels from earliest times. Done in a popular style, for ages 10 and up. The price is $2.75.

N.B. There is a charge for this book. Make checks payable to Spencer, White & Prentis, Inc.

170 UNDERGROUND PIPE CLEANING

Flexible, Inc.—Catalog 55-A describes equipment, tools, and methods for cleaning sewers, storm drains, etc. Catalog 55-B describes a complete line of water main, oil, and industrial pipe cleaning tools. Catalog 55-C describes equipment and tools for cleaning underground telephone, power company and signal ducts. Catalogs will only be sent to those submitting details of their cleaning problem. In addition to the catalog, factory engineers will make specific recommendations for cleaning your pipe.

171 UNDERPINNING

Spencer, White & Prentis, Inc.—"Underpinning," a book by Edmund Astley Prentis and Lazarus White. Recognized as the authoritative source for information in the field by engineers, architects and contractors all over the world. The price is $10.

N.B. There is a charge for this book. Make checks payable to Spencer, White & Prentis, Inc.

172 UNDERWATER SURVEY DEPTHOMETERS AND METAL LOCATORS

Bludworth Marine—The recent supersonic survey recorder, which makes underwater surveys faster and more accurate, is described in bulletins published by the company. It works well on channel dredging salvage or coastal construction jobs. It reveals the character of bottom material while recording depth. The Underwater Metal Locator, also explained in recent literature, detects ferrous and non-magnetic metallic objects. Almost buoyant, it weighs only $1^1/_2$ pounds submerged. It can be handled easily by professional and skin divers, and salvage operators.

173 UPWARD-ACTING DOORS

The Kinnear Manufacturing Co.—The catalog and data book discusses fully and illustrates the advantages, the economy, the construction features and the general specifications of the various types of wood and steel upward-acting type doors. Known as Bulletin 83, it gives information on installation clearance requirements, methods of operation and controls, as well as adaptability of the doors for many types of uses.

174 USE AND CARE OF WIRE ROPE

Leschen Wire Rope Division—Has published a seventy page booklet, C-51, covering all aspects of the handling of wire rope. Among the topics discussed are: installations, splicing, measuring and constructions of wire rope. An index is provided for the benefit of the reader in which over forty topics are listed in this handbook of practical information on wire rope.

175 VALVES

Lunkenheimer Co.—New 3-color illustrated folder, Circular 602, describes uses, performance and lists sizes of Lunkenheimer's new LQ600 Bronze Globe Valve with integral seats and discs of Lunkenheimer's exclusive "Brinalloy." It explains how the new flat seats and discs need no maintenance, never require replacement or regrinding.

176 VERTICAL DRILLS

The Salem Tool Company—A 4-page, 2-color brochure explains the new heavy-duty drill Model 106-24 which is a companion drill to the 106-8. The vertical drills meet the requirements of weight, ruggedness, ease of operation, and versatility, and may be used in highway and turnpike construction, seismograph work, strip mine operation and stabilizing hillsides and dams. A specifications chart is included.

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177 VERTICAL PUMP

Johnston Pump Company—A technical manual, almost seven years in the making, and the only one of its kind which fully covers the vertical pumping industry, is now available. Compiled by leading authorities in the field of ground water and pump engineering, it has been published in order that the full advantages of the use of vertical turbine pumps may be better known and better utilized. It outlines basic design principles and operating characteristics and should be a great help in enlightening design engineers to vertical pump benefits. The book would be a valuable addition to any technical library. The price is $10.00.

N. B. There is a charge for this book. Make checks payable to Johnston Pump Company.

178 VIBRATORS

Viber Company—There are available reprints of case history ads and a pamphlet: "How to apply, operate, and maintain external vibrators in the manufacture of concrete pipe."

179 WALL-FORM CONSTRUCTION

Symons Clamp & Mfg. Co.—Offers a brochure on its system of wall-form construction. Latest information and improvement in the Symons Forming System are given. Illustrations show in detail: how simply and easily the forming system operates; actual construction where forms have been used; the forms are shown in use as in completed jobs, also contains detailed information on Safety Shores and Column Clamps. Symons Engineering Department prepares, free-of-charge, form layouts, bills of material and cost sheets for new jobs.

180 WATER BATCHERS

The Heltzel Steel Form & Iron Co.—A completely descriptive pamphlet giving full details as to the operation of the new Heltzel semi-automatic Water Batcher that permits faster, more accurate water control in concrete batching.

181 WATER DAMAGE CONTROL

Western Waterproofing Co., Inc., of Missouri—A practical, professional treatise on water damage control, written by an expert in the field, especially for church property administrators. In 6 pages of pictures and text the author discusses three basic types of treatment—preventive, remedial and restoration—and how and when they should be applied to the five common classes of construction usually found in church buildings—old brick, new brick, stone, concrete and precast block.

182 WATER FILTERS

Proportioneers, Inc.—Bulletin 1800-3 describes Purecel Diatomite Filters for use in filtration of water in municipal and industrial water works and in swimming pool recirculation systems. Engineering data on the application of these filters including specifications and dimensions covering the complete recirculation and purification systems are given.

183 WATERPROOFING

Sika Chemical Corporation—A brochure describes quick-setting compounds and methods for use in sealing pressure leakage, through concrete and masonry in tunnels, tanks and deep basements.

184 WATERPROOFING SERVICES

Western Waterproofing Co., Inc. of Missouri—A folder explains the "when, why and how" for specifying waterproofing services to protect new and old structures from above-grade water penetration, interior wall dampness and subsurface water seepage. Deals specifically with such problems as wet walls, shrinkage in brickwork foundation water seepage and describes the scope and method of protection or restoration work that should be specified for each.

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185 WATER, SEWAGE AND WASTE

Hardinge Company, Inc.—Has published a new 20-page catolog on their line of equipment for water, sewage and industrial waste treatment, Bulletin 35-D. The catalog shows details of construction and specifications for Hardinge Circular Clarifiers, up to 200 ft diameter, and Hardinge rectangular clarifiers with crane type scraping mechanism. Equipment applications discussed in the catalog include municipal sewage and water treatment, industrial water treatment and liquid waste treatment.

186 WATER, SEWAGE, AND WASTE TREATMENT

B-I-F Industries, Inc.—A 24-page, 2-color booklet, Bulletin B-I-F 6 offers a complete line of Blue Chip Quality Products for the treatment of water, sewage and waste. The products offered include meters and instruments, feeders processes equipment, controls, and filters and filter operating equipment.

187 WATERSTOPS

Water Seals, Inc.—Offers a colorful 8-page brochure illustrating a complete line of waterstops along with the particular job application of each. Polyvinyl waterstops are flexible enough to withstand extreme joint separation, yet are rigid enough to stand up to the battering effect of pouring concrete. The stops are unaffected by acid, alkalies, petroleum products, chemicals or adverse atmospheric conditions and will not rust, rot, check or crack.

188 WELLPOINT DEWATERING

Griffin Wellpoint Corporation—"The Wellpoint System in Principle and Practice" is a handbook on the fundamentals of wellpoint dewatering and is applicable to any wellpoint system regardless of manufacture. This handbook is now available and contains information on how a wellpoint system functions, and methods of planning, layout, installation and removal of the system. The manual is pocket size, 109 pp. in length and contains 62 diagrams and illustrations.

N. B. Contractors and engineers can obtain this book free by sending requests on their letterheads. Others must pay charge of $1.50 by sending check payable to Griffin Wellpoint Corporation.

189 WELLPOINT SYSTEM

Moretrench Corporation—A new, informative 76-page catalog, fully illustrated, describes the Moretrench Wellpoint System and its use in dewatering various types of construction projects. It includes useful technical data on the system.

190 WELLPOINT UNWATERING SYSTEM

John W. Stang Corporation—A new 100-page revised edition of this catalog describes the component parts of the Stang wellpoint unwatering system; its planning, engineering and various methods of installation. Numerous recent projects have been added to demonstrate either a new application or some novel technical feature in the engineering and installation of the wellpoint equipment. Specific installations on dams, powerhouses, pipelines, tunnels, are illustrated from photographs made in the field. Heavy construction of all types in all varieties of soil conditions where ground water is encountered is described fully.

191 WIRE ROPE HANDBOOK

Leschen Wire Rope Division—This new concise handbook, R-51, contains complete tables of the weight and strength of all standard constructions of Leschen Wire Rope together with many details of strand and rope construction. It is a handy, pocket catalog.

192 ZEOLITE WATER SOFTENERS

The Permutit Company—Bulletin No. 2386A describes troubles caused by the utilization of hard water and the multiple economies effected by curing them are thoroughly discussed in this comprehensive 20-page bulletin. The bulletin lists several industries where steam and water are of importance and should be of interest to all engineers dealing with water problems. Specifications, operating characteristics and typical installation photographs have been included in this revised edition.

PROCEEDINGS AVAILABLE

For Instructions and Key to Abbreviations, see next page. Each member is entitled to 100 free "Proceedings Papers" yearly, ordered from these pages, plus all papers of the Technical Division in which he registers. The latter papers will be mailed automatically. To register, mail the enrollment form on page 197 to Society Headquarters. Discussion of a paper will be received during the three full months following the month of issue.

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782. **Discussion of Proceedings Papers 392, 552, 645. (SA)**

783. **Flood-Erosion Protection for Highway Fills, by C. J. Posey. (HW)** A method is described for constructing highway fills to prevent damage by inundation, even when accompanied by high velocities of flow over the grade or along the side slopes. Preliminary investigations shed new light on the mechanism of failure of erosion protection.

784. **Manpower Factors in an Augmented Highway Program, by Robert Horonjeff, Norman Kennedy, and Harmer E. Davis. (HW)** The prospect of an augmented program of highway construction raises serious problems of engineering manpower. Possibilities of the segregation of professional and nonprofessional functions and the utilization of specially trained personnel for the latter are discussed. Suggestions are made concerning the possibilities of and need for the development of further streamlined procedures and devices for reducing manpower requirements.

785. **Urban Renewal and the Rebuilding of American Cities, by J. W. Follin. (CP)** The urban renewal program authorized by the Housing Act of 1954 indicates three methods of attack: Prevention of the spread of blight, rehabilitation of salvable areas, and clearance and redevelopment of nonsalvable slums. Federal aids available under the act and community steps in undertaking an urban renewal program are outlined.

786. **Tightening High-Strength Bolts, by F. P. Drew. (ST)** A method is described in this paper whereby one turn of the nut from a "finger tight" position can be the criterion of bolt tension. A high clamping force is developed, and the effectiveness of the fastener is increased. Tightening bolts by this method can be simply effected.

787. **McNary Dam—Design from Technical Considerations, by H. L. Drake, G. C. Richardson, H. M. Rigler, and R. A. Schuknecht. (PO)** This paper, the second of a series on the McNary project, considers some of the design problems encountered from the points of view of foundations, hydraulics structures, and power facilities. Among these problems were the design of a spillway with vertical lift split gates, the highest single lift lock in the world, a power plant rated at 980,000 kw, and modern fish-passing facilities.

788. **Riverbed Degradation Below Large Capacity Reservoirs, by M. Gamal Mostafa. (IR)** A simple method for predicting the condition of equilibrium of a riverbed subject to degradation is presented. It is suggested that the rate of degradation be computed by a trial method. An objective of the paper is to invite comment that may illuminate the problem.

789. **Engineering Problems in U. S. Tidal Waterways, by J. H. Douma. (HY)** Problems arising in locating, designing, and maintaining improved tidal waterways in the United States are reviewed and illustrated. The design criteria, methods of coping with problems, and maintenance practices of the Corps of Engineers are considered.

790. **Operation of Whitney Reservoir During the Filling of Power Pool, by Charles Miron. (HY)** The paper relates the problems encountered during the initial filling of the Corps of Engineers' reservoir on the Brazos River in Texas. During the summer of 1952, water released from Whitney reservoir on a loan basis to the Brazos River Authority was credited with saving the year's rice crop. Water advanced from Whitney reservoir reduced the time required for delivery of irrigation water by several days.

791. **Flow Geometry at Straight Drop Spillways, by Walter Rand. (HY)** Characteristic length terms of the flow pattern at a straight drop spillway are represented as functions of the drop number D, a dimensionless ratio of the discharge, the drop height, and the acceleration of gravity. A simple logarithmic plot representing these relationships minimizes computation. The theoretical considerations are supported by results of model studies.

792. **Some Effects of Upland Discharge on Estuarine Hydraulics, by Henry B. Simmons. (HY)** This paper is principally concerned with certain broad relationships between the volume of upland discharge into estuaries and their hydraulic and shoaling regimens.

793. **Hydrograph Analysis by the Method of Least Squares, by Willard M. Snyder. (HY)** Hydrographs of storm runoff produced by complex rainfall patterns can be analyzed to obtain coefficients which characterize the time distribution of runoff occur-

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ring in unit time. By an iterative procedure the distribution coefficients and the hydrograph can be used to compute the volume of runoff occurring in each time unit.

794. Discussion of Proceedings Papers 482, 535, 565, 566, 667, 678. (HY)

795. Elastic Instability of Flat Plates Subjected to Partial Edge Loads, by Lev Zetlin. (EM) Buckling loads of flat rectangular plates subject to loads distributed over short parts of the edges are determined. The equations governing the buckling loads are considered and an approach to the solution is made by means of the energy method. Results of computations have been reduced to curves suitable for design purposes. These curves are given for a wide range of plate dimensions and loading widths. The theoretical results are compared with those of a number of tests.

796. An Experimental Study of Boundary Layer Transition, by H. W. Bennett and Charles A. Lee. (EM) Transition on a smooth flat plate in a zero pressure gradient was studied in a wind tunnel using conventional surface tube and hot wire techniques. The effect of free-stream turbulence was studied in terms of the energy concentrated at the amplified frequency.

797. Lateral Buckling of Rolled Steel Beams, by R. A. Hechtman, J. S. Hattrup, E. F. Styer, and J. L. Tiedemann. (EM) This investigation of the lateral buckling of rolled steel beams under transverse loading included 10-in., 12-in., and 18-in. beams simply supported or bolted by semirigid connections. Good correlation was found between the theoretical and the actual buckling strength for the more slender beams.

798. Soil Mechanics and Work-Hardening Theories of Plasticity, by D. C. Drucker, R. E. Gibson, and D. J. Henkel. (EM) It is suggested that soil be treated as a work-hardening material which may reach the perfectly plastic state. A good qualitative agreement with the known behavior of soils in triaxial tests is thus obtained.

799. Discussion of Proceedings Papers 529, 670, 671, 677. (EM)

800. Missouri River Basin Plan in Operation, by Wendell E. Johnson. (WW) This paper reports progress made since World War II on the water resource program undertaken in the Missouri Basin. Many projects are already in operation, and the benefits of flood control, power generation, irrigation, and navigation are being realized increasingly each year as new features of the program are added.

801. Control of Arroyo Floods at Albuquerque, New Mexico, by Rufus H. Carter, Jr. (WW) After thunderstorms of high intensity, flows of short duration but high peak from arroyos flood nearby valleys. This paper includes proposals for two diversion channels designed to convey flood flows around densely populated high-value lands.

802. Upper Minneapolis Harbor Development, Minnesota, by L. G. Yoder. (WW) The improvement of the upper Mississippi River (to provide a minimum channel depth of nine feet) includes two locks, channel dredging, removal of an existing dam, improvements to another, and construction of a new dam. The work is complicated by unfavorable geology and by the necessity for close control of water levels between the two locks. The history of the development and the principal factors influencing design are described in detail.

803. Flood Control in the Middle Mississippi, by Walter F. Lawlor. (WW) In the Middle Mississippi, the flood problem is of major importance because of the industrial and agricultural development of the valley. The efforts of local interests through organized levee districts, supplemented by major assistance under federal flood control policy, will provide economical and practicable protection.

804. Stiffening Lock Gates by Prestressing Diagonals, by Carl L. Shermer. (WW) This paper presents a method for the control of the warping or twisting of mitering-type navigation lock gates which occurs when the gates are swung through the water. The gate leaf is analyzed torsionally, and the function of the diagonal members in resisting torsional forces is explained. Expressions for torsional deflection and corresponding stresses in the diagonal members are developed. The application of theory to design and the field technique for prestressing are presented.

805. Protection of Subsiding Waterfront Properties, by Robert R. Shoemaker. (WW) An extensive land subsidence problem in some highly developed waterfront areas in Los Angeles County is considered, and methods of protecting the subsiding properties are outlined. The nature of the problem, individual examples of remedial measures, and some economic aspects are described.

806. Ground Water Phenomena Related to Basin Recharge, by Paul Baumann. (HY) The Los Angeles County Flood Control District has caused approximately 1,200,000 acre-ft of potable water to be added to the ground-water supply by percolation from basins in off-channel spreading grounds and by injection through wells. Phenomena related to these activities are described in this paper; a review of previously developed theory is made, and its practical application is sketched.

807. Discussion of Proceedings Papers 517, 700, 740. (PO)

808. Discussion of Proceedings Papers 404, 462, 620, 623, 728. (IR)

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